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Mining spillovers and the formal–informal duality in manufacturing and services

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Abstract: This study examines the effects of mining productivity shocks on the formal–informal duality in manufacturing and services. Using firm census data from 2014 for Ghana, we measure the rates of informality along extensive (unregistered firms) and intensive (registered firms hiring labourers 'off the books') margins. We find that the changes in the rates of informality along both margins across sectors following mining shocks are heterogeneous. We also find that the lack of duality between informal and formal firms across the development phases of mining is driven by increasing heterogeneity in productivity and skilled employment within informal and formal firms, and less by the incidence of firms sorting into the formal and informal sectors. The lack of duality was most noticeable among heavy manufacturing firms established after the start of oil and gas production in 2010, driven by more-productive newly established unregistered firms with lower labour and energy cost shares than newly established registered firms.

Key words: mining, informality, firm productivity, Ghana

JEL classification: D22, E26, J46, L14

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1 Introduction

The presence of a large informal sector is a common feature of developing economies. Based on data from several countries, the literature documents that informal firms, on average, are smaller (in terms of employees and revenue) and less productive, pay lower wages, hire less-educated workers, and earn lower profits than formal firms (de Paula and Scheinkman 2011; La Porta and Shleifer 2008, 2014; Perry et al. 2007; Rauch 1991). The theories supporting the dualistic view interpret the differences between formal and informal firms as being the result of burdensome entry requirements in the formal sector, which force formal and informal firms to operate in different economic spaces and produce different products (La Porta and Shleifer 2008, 2014).

Recent studies challenge the dualistic view, both theoretically and empirically. In a framework with heterogeneous firms exploiting the extensive (unregistered firms) and the intensive (registered firms hiring labourers 'off the books') margins of informality, Ulyssea (2018) shows that policy changes can have opposite effects on informal firms and informal labour. This is due to the intensive margin of informality, which captures subtler effects of policy changes. As such, the basis for a formal–informal duality, which has typically been modelled as burdensome entry requirements in the formal sector,[1] can be the heterogeneity among informal firms facing different regulations. Evidence from Brazil (Meghir et al. 2015; Ulyssea 2018) and India (Allen et al. 2018) shows substantial overlap in formal and informal firms' productivity distributions even within narrowly defined industries.[2]

Growing evidence on the lack of formal–informal duality raises several important questions. For example, how do the rates of informality along the extensive and intensive margins respond to exogenous sectoral productivity shocks? Do informal firms gain more from sectoral productivity shocks than their formal counterparts, which in turn reduces the differences between formal and informal firms? These issues are meaningful for public policies that aim to alter the degree of informality.

This study examines the effect of mining productivity shocks on the rates of informality along the extensive and intensive margins and the level of formal–informal duality in manufacturing and services in Ghana. We evaluate the effects of two exogenous events: the beginning of large-scale gold production in 2003 and the start of oil and gas production in 2010. Gold mining in Ghana dates to the fifteenth century; however, gold production stabilized only after 2003, with annual gold production increasing by a large margin compared with previous years (Fafchamps et al. 2017). Following the discovery of offshore oilfields in 2007, Ghana started extracting oil in commercial quantities in 2010 (Oxford Institute for Energy Studies 2019). The country's cumulative oil production increased steadily from 1.2 million barrels in 2010 to 508.4 million barrels in 2021 (PIAC 2021).

The primary aim of this study is to understand whether mining productivity shocks cause an increase in the productivity of, for instance, the chemical industry, which is a heavy user of mining inputs. The study then analyses whether the productivity shocks (i) increase the rates of informality along the extensive and intensive margins in the chemical industry and (ii) affect the productivity of formal and informal chemical firms. Informality in mining is widespread among low-income

[1] See De Soto (1989), Farrell (2004), and Levy (2008), among others.

[2] Relatedly, Hsieh and Olken (2014) do not find any evidence of the 'missing middle', which is closely linked to the dualistic view, in firm size distributions in the manufacturing sectors of Brazil, India, and Indonesia.

countries and is well documented (Rothenberg et al. 2016); however, the role of mining in informal activities in other sectors has been understudied. The growth of mining activities in Ghana coincided with an increase in the share of employment in industry from 16 per cent in 2010 to 20 per cent in 2018. This was largely driven by the creation of new firms and an increase in the average employment in firms in the heavy manufacturing industry that show the strongest intersectoral linkages with mining (Paul and Raju 2023).[3] We are particularly interested in understanding whether the expansion in the extent of heavy manufacturing has also affected the formal–informal duality in this sector.

To identify mining productivity shocks, we classify firms into three birth cohorts according to the three phases of mining development, 1990–2002, 2003–09, and 2010–13, based on information on the year of commencement from the 2014 Integrated Business Establishment Survey (IBES), a census of firms in industry and services for Ghana (GSS 2016). We refine our identification strategy by considering the intersectoral linkages between mining and other sectors. Using the IBES data, we compute (i) the rate of informality along the extensive margin (firms with no formal registration) and (ii) the rate of informality along the intensive margin (registered firms that use informal accounting practices) (Ulyssea 2018).

We compare the change in the rates of informality along the extensive and intensive margins, firm productivity, and skilled employment in both informal and formal firms between the firm birth cohorts of 1990–2002 and 2003–09 and across different industries (e.g., heavy manufacturing and light manufacturing) to identify the effect of the stabilization of gold production since 2003. Similarly, we compare the above-mentioned statistics between the firm birth cohorts of 2003–09 and 2010–13 and across different industries to identify the effect of the mining shocks led by oil and gas and more intensified gold production since 2010.[4]

As a further refinement to our identification strategy, we consider the spatial pattern of the mining shocks in Ghana. We compare the characteristics of firms between the south and the north of Ghana as the mining shocks occurred primarily in the south of the country (Paul and Raju 2023). This empirical strategy is in line with the place-based development literature that aims to understand how economic activities are organized in and around a particular location through market integration (Aragon and Rud 2015; Fafchamps et al. 2017; Kline and Moretti 2014; Moretti 2010). Ghana provides an ideal case to study local-level activities as there is no large flow of internal labour-related migration across regions in Ghana. Based on data from the 2016/17 Ghana Living Standards Survey (GSS 2019), only 6.2 per cent of the working-age population has moved from their birth region to another region due to self-reported employment-related reasons.[5]

The evidence based on descriptive statistics indicates a strong spatial correlation between the growth of mining and other sectors. The correlation between the number of new firms in mining and manufacturing and services became stronger in the last phase (2010–13) compared with the previous two phases of mining growth. Rates of informality along both the extensive and intensive margins have increased across the subsequent phases of mining development. The rate of informality along the intensive margin has increased more than the rate of informality along the

[3] Heavy manufacturing refers to manufacturing of coke and refined petroleum, chemicals, basic metals and fabricated metals, machinery and equipment, motor vehicles, and other transport vehicles, among others.

[4] A landmark initiative known as Operation Vanguard was undertaken by the Ghanaian government to safeguard the environment and bodies of water from illegal mining, known as '*galamsey*'. Operation Vanguard has resulted in the arrests of hundreds of illegal miners (Plaza-Toledo 2021) and helped to intensify gold production in Ghana since 2003.

[5] Self-reported employment-related reasons include seeking employment or establishing a business; they also include job relocation or job transfers.

extensive margin over time. This finding is in line with the evidence from Brazil (Ulyssea 2018). We also find that the changes in the rates of informality along both margins have become increasingly concentrated in the south of Ghana, closely aligned with the regional pattern of the mining shocks.

The above-mentioned findings on informality across sectors are heterogeneous. Oil and gas production have played a crucial role in increasing the rate of informality along the extensive margin in services in both the south and the north of the country, whereas the rate of informality along the intensive margin has increased in heavy manufacturing and wholesale and retail trade (WRT) services following the mining shocks only in the south. Mining productivity growth influences the heterogeneity in productivity within informal and formal firms, as well as the heterogeneity in productivity and share of skilled employment between informal and formal firms across sectors. Collectively, all these factors contribute to the lack of duality between formal and informal firms.

Similar to Paul and Raju (2023), we find that the effect of mining shocks on firm productivity is larger in heavy manufacturing than in other sectors. In addition, we find that younger, unregistered firms that were established after oil and gas production started in 2010 are more productive than younger, registered firms in heavy manufacturing. The lack of a formal–informal duality is most noticeable in heavy manufacturing, which is primarily driven by younger informal firms. Overall, the positive mining shocks appear to have created a level playing field for informal and formal firms, especially in heavy manufacturing in Ghana.

After experiencing decades of deindustrialization and growth-inhibiting structural transformation (Fosu 2017; Nxumalo and Raju 2020; Osei et al. 2020; Paul and Raju 2021), Ghana's growing petroleum-based economy is exposed to the perils of the Dutch disease (Aryeetey and Ackah 2018; Corden and Neary 1982; Osei et al. 2020; Ross 2012), high natural resource dependency (Nnadikwe 2011), and informal mining (Plaza-Toledo 2021). The current study presents some positive results of the mining boom in Ghana.

We make two substantive contributions. The first contribution is related to the large literature on informality (de Paula and Scheinkman 2011; La Porta and Shleifer 2008, 2014; Perry et al. 2007; Rauch 1991). This study is specifically linked to an emerging subfield of informality research that aims to deepen our understanding of the formal–informal duality (Allen et al. 2018; Meghir et al. 2015; Ulyssea 2018). To our knowledge, this study is the first to provide evidence on the formal–informal duality and the role of mining productivity shocks in the context of a sub-Saharan African country. We provide evidence of the role of mining in the changing pattern of the duality between informal and formal firms in manufacturing and services in Ghana.

The second contribution is related to the literature on the local-level effect of mining on labour market outcomes in low-income countries (Fetzer 2014; Feyrer et al. 2017; Michaels 2011; Paul and Raju 2023; Toews and Vezina 2020; Tsvetkova and Partridge 2016).[6] The local-level effect of mining in developing countries shows mixed results on employment, firm productivity, and living standards. Some studies find positive employment multiplier effects of mining (Fafchamps et al. 2017; Michaels 2011; Toews and Vezina 2020), whereas others find negative effects on employment (Kotsadam and Tolonen 2016) and the business environment, especially for firms in the tradeable goods sector (De Haas and Poelhekke 2019). Kilumelume et al. (2022) show that a negative shock in the mining sector reduces both employment and wages in related service

[6] Marchand and Weber (2018) provide a comprehensive review on this topic.

industries. We extend this literature to examine how the local-level effects of mining are linked to the rates of informality along the extensive and intensive margins in manufacturing and services.

The remainder of the paper is organized as follows. Section 2 presents an overview of the mining sector and the process of industrialization in Ghana. Section 3 discusses the results on the rates of informality along the extensive and intensive margins. Section 4 discusses the results on the formal–informal duality, such as the role of mining productivity shocks in the change in productivity and skilled employment for informal and formal firms in manufacturing and services. It also provides results on the changing pattern of firms sorting into different sectors. Section 5 discusses results on the possible channels linking mining productivity and informality. Section 6 concludes.

2 Mining and industrialization in Ghana

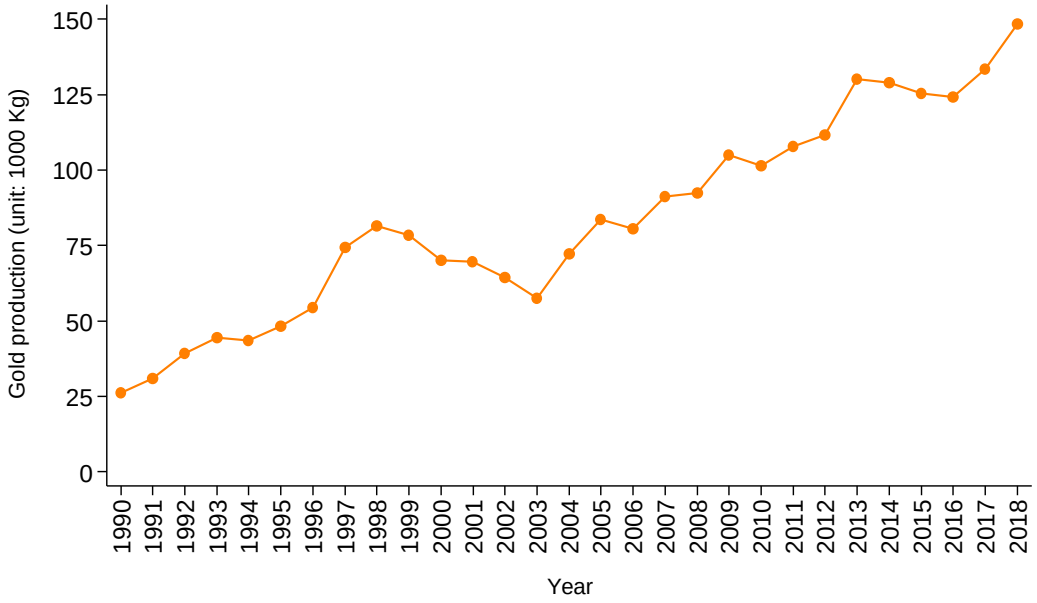
This section provides an overview of the recent mining boom in Ghana, followed by a brief account of the pattern of structural transformation in Ghana between 2000 and 2018.

2.1 The three phases of mining development

Ghana has a wide range of mineral resources. While gold, manganese, bauxite, diamonds, and oil and gas have so far been exploited on a large scale, the reserves of copper, limestone, and iron ore remain mostly unexploited (Maier et al. 2023). Gold mining is the oldest extraction industry in Ghana, which started in the mid-fifteenth century during the colonial era. Production of manganese resumed in 1916, followed by diamonds in 1919, and bauxite much later in 1942. In 2017, Ghana became the second largest producer of gold, accounting for 4 per cent of the world's gold production. However, gold production in Ghana was unstable between 1995 and 2003 (Figure 1). The first peak in production was achieved in the late 1990s, and after a drop in the early 2000s, gold production again picked up in 2003 and continued to increase until 2018. Production of gold increased by 12 per cent in 2017 (USGS 2019). During this period, gold mining activities shifted from the Ashanti, Central, and Eastern regions to the Western region, primarily because of the closure of many gold mines in the first three regions (Fafchamps et al. 2017).

The first discovery of oil and gas in Ghana was in the 1970s. As the volume of extraction was modest until the turn of the twenty-first century, the production of oil and gas during this period was mostly non-commercial. In 2007, after decades of exploration, Ghana discovered oil in large quantities in the oilfields in Deepwater Tano and the West Cape Three Points block. In November 2010, the Jubilee Partners (comprising Tullow Oil, Kosmos Energy, Anardako Petroleum Corporation, Sabre Oil and Gas, E.O. Group, and Ghana National Petroleum Company) started extracting and producing oil in commercial quantities. Several other oilfields were discovered between 2010 and 2020, including Tweneboa Enyenra Ntomme in 2016 and Sankofa Gye Nyame in 2017. The oil industry in Ghana has progressed steadily despite the downturn in international oil prices in 2014. The country's volume of cumulative oil production continued to increase from 1.2 million barrels in 2010 to 508.4 million barrels in 2021 (PIAC 2021) (Figure 2). As offshore mining has continued to thrive, Ghana is now aiming to explore onshore oilfields and gas fields across several locations in the Voltaian Basin (Skaten 2018).

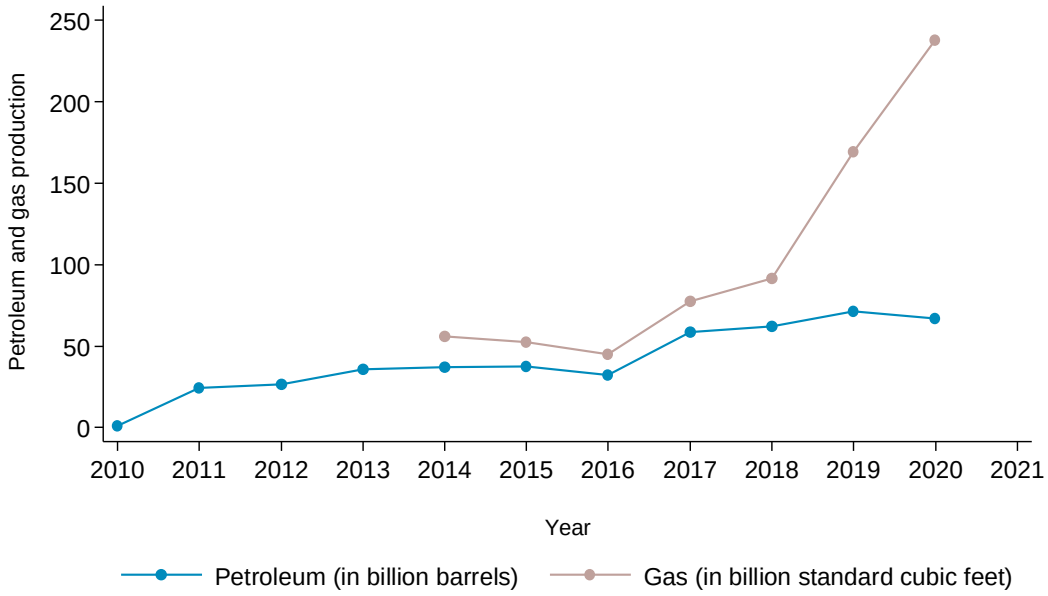
Figure 1: Gold production in Ghana, 1990–2018



Note: gold production figures include reported artisanal and small-scale output.

Source: authors' estimates based on statistics from the US Geological Survey database (USGS 2019).

Figure 2: Annual petroleum and gas production in Ghana, 2010–21



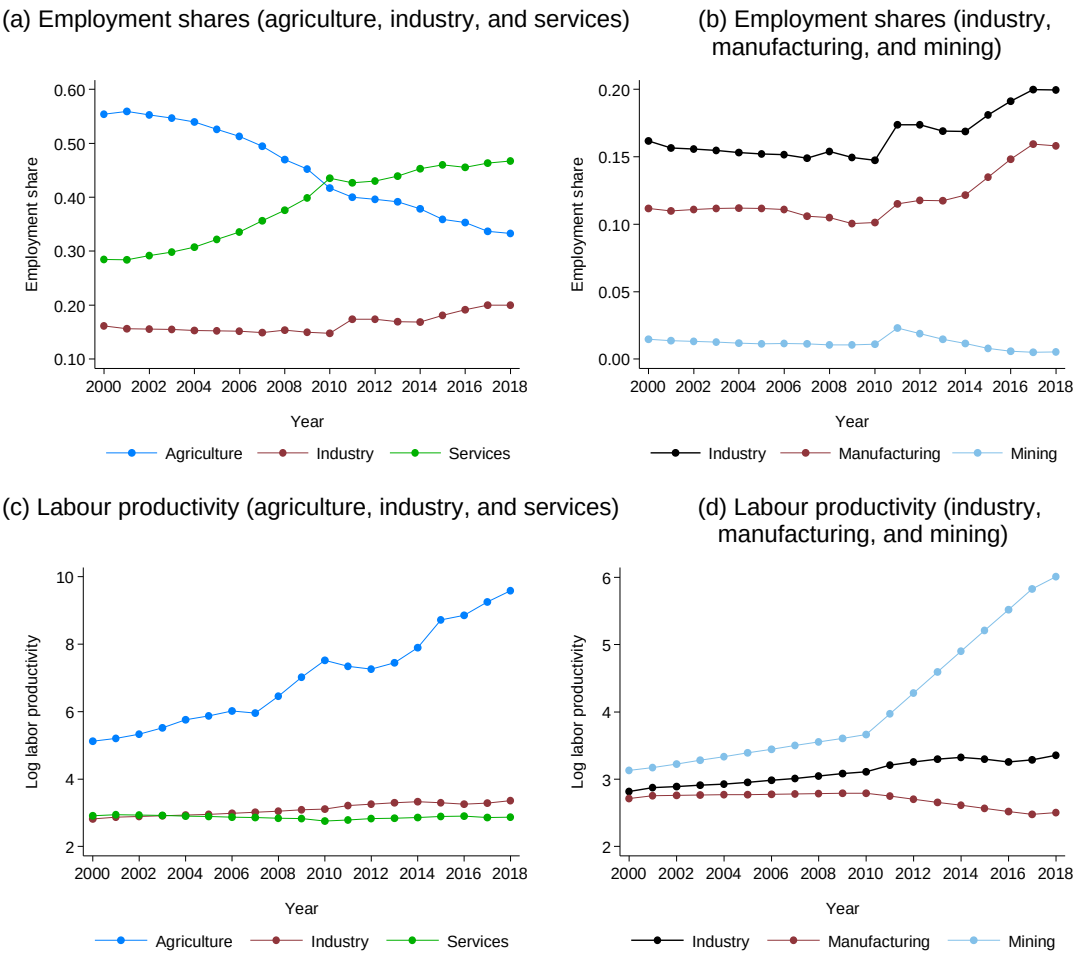
Source: authors' estimates based on information obtained from PIAC (2021).

Figures 1 and 2 point to three distinct phases of development in Ghana's mining sector. The first phase, from 1990 to 2002, shows volatility in gold production. The second phase, from 2003 to 2010, exhibits steady growth in gold production. The third phase marks the start of natural oil and gas production and more intensified and large-scale production of gold from 2010 onwards. In the next section, we discuss the aggregate trends in Ghana's industrialization process.

2.2 Ghana's industrialization drive

We present the aggregate trends in mining and manufacturing for 1990–2018 based on the GGDC/UNU-WIDER Economic Transformation Database (ETD).[7] Using the ETD data, we analyse sectoral trends in employment, value added, and labour productivity. Figure 3 provides a picture of employment and labour productivity (value added over employment) trends in broad sectors of activities between 2000 and 2018. The employment share in agriculture declined steadily (from 56 per cent in 2000 to 36 per cent in 2018) and the employment share in services followed an upward trend but the pace slowed after 2010 (Figure 3a). In contrast, the employment share in industry started to increase in 2010 and grew from 16 per cent in 2010 to 20 per cent in 2018, after being stuck at 16 per cent during the 2000s.

Figure 3: Trends in sectoral employment shares, value-added shares, and labour productivity, 2000–18



Note: industry includes mining, manufacturing, public utilities, and construction. Almost 95 per cent of industrial employment is in mining and manufacturing. Labour productivity equals value added divided by employment.

Source: authors' estimates based on statistics from the Economic Transformation Database (Kruse et al. 2021).

Figure 3b depicts the employment trends in industry and its subsectors, manufacturing and mining. Manufacturing and mining account for 95 per cent of employment in industry. The increase in the employment share in industry has been driven primarily by an increase in the employment share

[7] The ETD is a joint initiative of the Groningen Growth and Development Centre (GGDC) and the United Nations University World Institute for Development Economics Research (UNU-WIDER). It is a publicly available database, along with documentation on its contents and construction (see Kruse et al. 2022).

in manufacturing. Although employment in mining grew following the discovery and production of oil and gas in 2010, its employment share in industry declined between 2010 and 2018 because of the much larger expansion of employment in manufacturing.

Figure 3c compares the trends in log labour productivity, measured as value added per employment, among agriculture, industry, and services. A large movement of labour away from agriculture resulted in an increase in labour productivity in the sector between 2000 and 2018. Labour productivity in industry has increased slightly since 2010 despite the growing share of employment in industry. A closer look at industry and its subcomponents (Figure 3d) reveals that the trends in labour productivity across subsectors within industry started to diverge after 2010. The log labour productivity in mining almost doubled between 2010 and 2018, increasing from 3.5 in 2010 to 6.2 in 2018, as the value-added share of mining increased from 3 per cent in 2000 to 12 per cent in 2018 (9 percentage points). In contrast, the log labour productivity in manufacturing dropped slightly, from 2.8 in 2010 to 2.5 in 2018.

The evidence presented in Figures 1 and 2 suggests that the increase in labour productivity in industry is largely correlated with the growth of value added in mining. We now turn to the rate of entry of new firms and the level of informality in manufacturing and services across the phases of development in the mining sector.

2.3 Spatial and temporal growth of firms

Ghana's long history of conducting economic censuses of non-household registered firms dates to the 1960s. We use the 2014 IBES, a census of firms in industry and services, to compare the birth rate of new firms in mining, manufacturing, WRT services, and other services between 2003 and 2014 (GSS 2016). The 2014 IBES data allow us to trace the birth year of each establishment, with the caveat that our sample is restricted to the group of firms that were active in 2013–14.

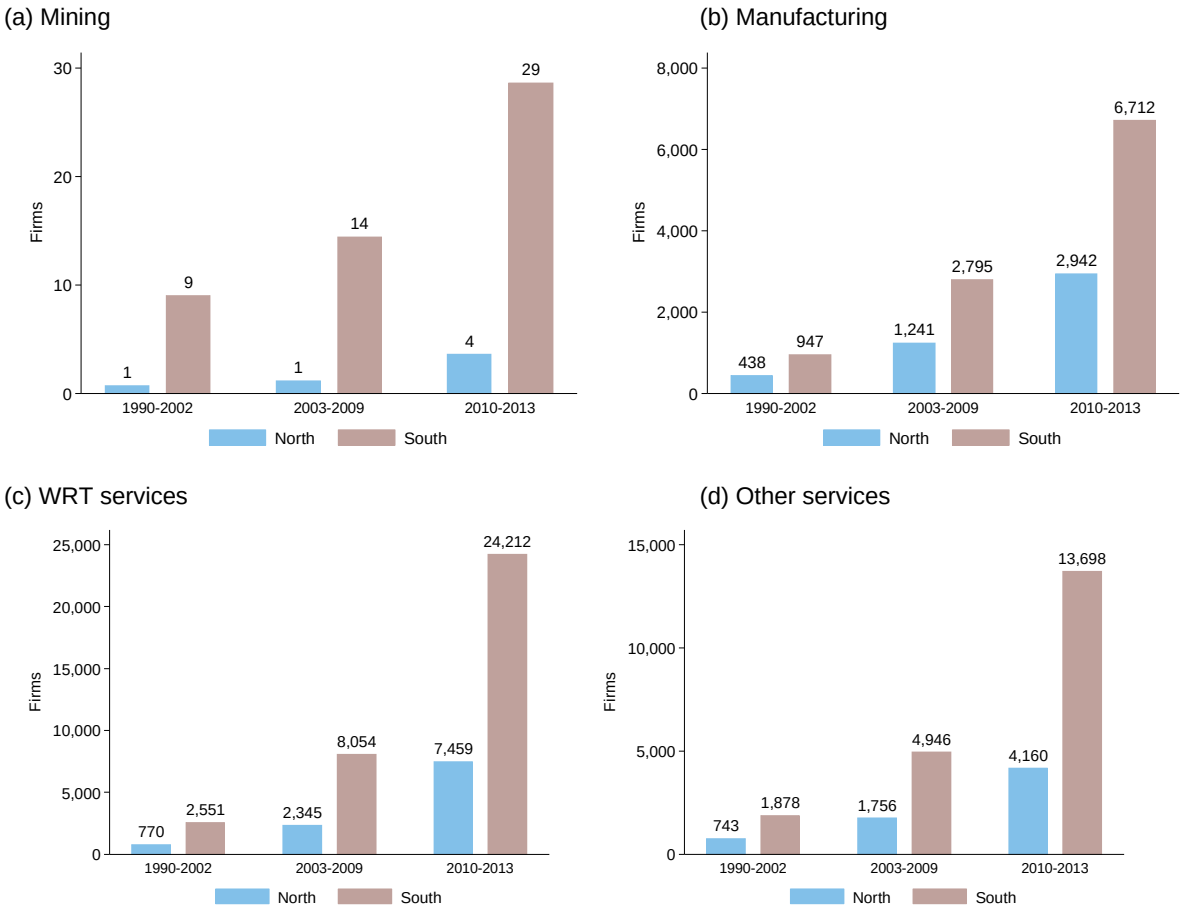
Figure 4 compares the entry of new firms in mining, manufacturing, WRT services, and other services across the three stages of mining development. Each bar in the figure presents the number of new firms born in a specific year during 1990–2014.[8] Figure 4a depicts the number of new mining firms. In the first phase (1990–2002), the number of new mining firms was on average fewer than 10; in the second phase of mining development (2003–09), this increased to 15; and since 2010, the average number of new firms per year increased to 30.

Note that almost 95 per cent of the new firms in mining are in the south of Ghana, suggesting that the mining shock occurred primarily in the south of the country, which had a much larger number of mining firms than the north of the country.

Gold mining in 2003 was limited to only a handful of districts in the Ashanti region of Ghana; however, mining activities spread across many districts predominantly located in the Southern, Western, Greater Accra, Eastern, and Ashanti regions (Paul and Raju 2023). At the same time, new gold mines were discovered in the Western region, following which the bulk of gold production moved from the Ashanti region to the Western region between 2003 and 2013. In some districts in the north of the country (in the Upper East and Upper West regions), increasing production of bauxite, copper, and other minerals led to growing mining activities between 2003 and 2013. Proximity to offshore oil and gas fields in the south also contributed to this spatial pattern.

[8] Since the 2014 IBES was fielded in April 2014, there were only about 300 new firms in 2014; therefore, we combined the figures from 2013 and 2014 as new firms in 2013.

Figure 4: New firms by sector and year of commencement



Note: mining industry includes firms in all mining sectors including gold, other minerals, and petroleum. Manufacturing includes all manufacturing industries. Services include firms in wholesale and retail trade (WRT) and other service industries. Based on the year of commencement, firms are categorized into Phase 1 (1990–2002), Phase 2 (2003–09), and Phase 3 (2010–13).

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

The mining industry grew alongside steady growth in downstream oil-marketing and manufacturing industries (Oxford Institute for Energy Studies 2019; Skaten 2018). This is supported by the evidence shown in Figure 4b. The entry of new firms in manufacturing from 1990 to 2002 (Phase 1) was moderately constant, except for the year 2000 when more than 4,000 firms were created. The rate of entry of new firms in manufacturing has increased gradually since 2003. With the production of oil and gas starting in 2010, the average rate of new firms reached more than 9,000 per year. Almost 75 per cent of the new firms in manufacturing are in the south of Ghana. This could be due to the organization of economic activities in and around a particular location through market integration and demand spillovers (Aragon and Rud 2013; Fafchamps et al. 2017). The growth of firms in WRT services (Figure 4c) and other services (Figure 4d) reflects similar trends observed for manufacturing. The entry of new firms in services has increased steadily since 2003, and the bulk of new service firms (nearly 80 per cent) are in the south of the country.

The evidence strongly suggests the occurrence of mining shocks alongside the steady growth of firms in manufacturing and services since 2003, primarily in the south of Ghana.

2.4 Firm productivity across the phases of mining development

As a final step to uncover Ghana's recent industrialization drive, we present some regression results for firm productivity. Our base identification strategy compares labour productivity (measured as sales per employee) at the firm level across three birth cohorts of firms: 1990–2002, 2003–09, and 2010–13. Since we measure labour productivity only in 2013, this reduced-form regression allows us to compare the difference in firm productivity across birth cohorts in 2013. Because of this data constraint, we are unable to estimate the change in productivity over time. We follow the classification of the manufacturing sector into light manufacturing and heavy manufacturing. Paul and Raju (2023) find that due to strong intersectoral linkages between mining and heavy manufacturing industries (chemicals, metals, non-metallic minerals, and machinery), the increases in the number of new firms and average employment have been stronger in heavy manufacturing than in light manufacturing following the mining shock in Ghana.

Table 1 presents the results of the base model. We find heterogeneity in the labour productivity gap across different cohorts of firms in the south of Ghana. In the south, the productivity gap between newer firms born after 2010 and older firms is largest in heavy manufacturing. The estimated coefficient of the productivity gap in heavy manufacturing (0.32) is two times larger than that in light manufacturing (0.14) and almost 1.5 times larger than that in WRT services (0.24). All coefficients are statistically significant at the 5 per cent level. In the north, the average productivity of newer firms born after 2010 is higher than that of older firms only in services. If the difference in production technology of firms across firm birth cohorts is linked to different phases of mining development, then the results suggest a strong correlation between oil and gas production and firm productivity in the south of Ghana.

To check whether the results of the base model on the productivity gap are causal, we perform placebo tests with two alternatives for the stages of mining development. We restrict the placebo tests to the south of the country because of the strong and statistically significant results on the productivity gap in this region. Table 2 presents the placebo test results for light manufacturing, heavy manufacturing, and WRT services. In the case where we set oil and gas production to start in 2008, the productivity gap between firms born before and after the start of oil and gas production remains unchanged across all sectors (the first row in Table 2). In the second case, we set oil and gas production to start in 2009. Similar to the first falsification test, the results in the second row (Table 2) show a negligible productivity gap between firms from different birth cohorts.

To conclude, the spatial and temporal features of firm creation across sectors characterize the stages of development in mining activities (Section 2.1) and the observed pattern of structural transformation (Section 2.2). The results suggest a strong positive effect of oil and gas production since 2010 on the productivity of younger heavy manufacturing firms born after 2010 in the south of Ghana.

Table 1: Correlates of log labour productivity by sector

	North				South			
	Light manufacturing	Heavy manufacturing	WRT services	Other services	Light manufacturing	Heavy manufacturing	WRT services	Other services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Phase (=1 if 2003–09, =0 otherwise)	−0.101	−0.154	0.047	0.084	0.007	0.068	0.125*	−0.015
	(0.076)	(0.145)	(0.060)	(0.075)	(0.060)	(0.101)	(0.070)	(0.062)
Phase (=1 if 2010–13, =0 otherwise)	0.061	0.170	0.169***	0.166***	0.143**	0.315***	0.241***	−0.035
	(0.079)	(0.121)	(0.047)	(0.059)	(0.057)	(0.097)	(0.077)	(0.085)
Capital	−0.009	0.032*	0.017*	0.064***	0.010	0.020	0.062***	0.041***
	(0.015)	(0.016)	(0.010)	(0.011)	(0.006)	(0.012)	(0.016)	(0.006)
Materials	0.394***	0.407***	0.635***	0.317***	0.413***	0.510***	0.435***	0.195***
	(0.037)	(0.078)	(0.027)	(0.017)	(0.024)	(0.041)	(0.041)	(0.042)
Constant	5.274***	5.142***	3.166***	5.713***	5.125***	4.140***	5.097***	7.369***
	(0.258)	(0.673)	(0.246)	(0.117)	(0.215)	(0.413)	(0.323)	(0.315)
N	1,493	488	2,388	2,243	1,903	805	2,714	4,527
R^2 statistic	0.495	0.491	0.732	0.379	0.507	0.605	0.577	0.271

Note: WRT, wholesale and retail trade. The dependent variable is log labour productivity (value added per worker). Each regression model includes district fixed effects. Standard errors are reported in parentheses. Significance level: *10 per cent, **5 per cent, ***1 per cent.

Source*:* authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

Table 2: Correlates of log labour productivity in the south by sector (placebo results)

	Light manufacturing	Light manufacturing	Heavy manufacturing	Heavy manufacturing	WRT services	WRT services
	(1)	(2)	(3)	(4)	(5)	(6)
Phase (=1 if 2008–09, =0 if 2003–07)	0.037		−0.091		0.100	
	(0.057)		(0.082)		(0.069)	
Phase (=1 if 2009, =0 if 2003–08)		−0.078		0.012		0.174
		(0.084)		(0.103)		(0.133)
Capital	0.014	0.014	0.021	0.022	0.071***	0.070***
	(0.010)	(0.010)	(0.024)	(0.024)	(0.025)	(0.025)
Materials	0.398***	0.398***	0.524***	0.524***	0.413***	0.413***
	(0.032)	(0.031)	(0.039)	(0.039)	(0.054)	(0.055)
Constant	5.230***	5.250***	4.028***	4.007***	5.331***	5.329***
	(0.267)	(0.272)	(0.405)	(0.396)	(0.418)	(0.425)
N	1,252	1,252	475	475	1,660	1,660
R^2 statistic	0.498	0.498	0.642	0.641	0.575	0.575

Note: the dependent variable is log labour productivity. Each regression model includes district fixed effects. Standard errors are reported in parentheses. Significance level: *10 per cent, **5 per cent, ***1 per cent.

Source*:* authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

3 Extensive and intensive margins of informality

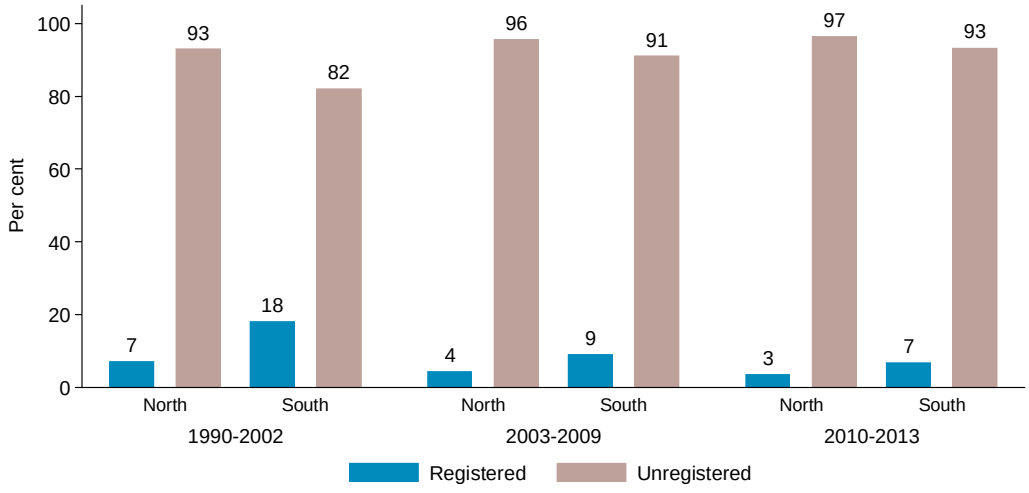
In this section, we examine the rates of informality along the extensive and intensive margins and analyse informality trends across the different phases of mining development. The Ghana Statistical Service (GSS) defines a firm as informal if it is not registered with the Registrar General's Department and does not maintain its financial accounting records professionally (GSS 2016). The GSS's definition of informality combines the extensive and intensive margins of informality (Ulyssea 2018), but we consider them separately in this study. We define the margin of informality as extensive if a firm is not formally registered with the Registrar General's Department and the margin of informality as intensive if a registered firm maintains accounting records informally or keeps no accounting records.

Figure 5 plots the distribution of new firms by registration status across different sectors. Among older manufacturing firms born between 1990 and 2002, the rate of registration in the south of the country (18 per cent) was more than two times the rate in the north (7 per cent). With the growth of the mining sector, the registration rate of manufacturing firms dropped in both the south and the north of Ghana. We observe some regional differences. The rate of informality along the extensive margin in the south increased by 11 percentage points (from 82 per cent in the 1990–2002 cohort to 93 per cent in the 2010–13 cohort), which is larger than the 4 percentage point change in the north (from 93 per cent in the 1990–2002 cohort to 97 per cent in the 2010–13 cohort).

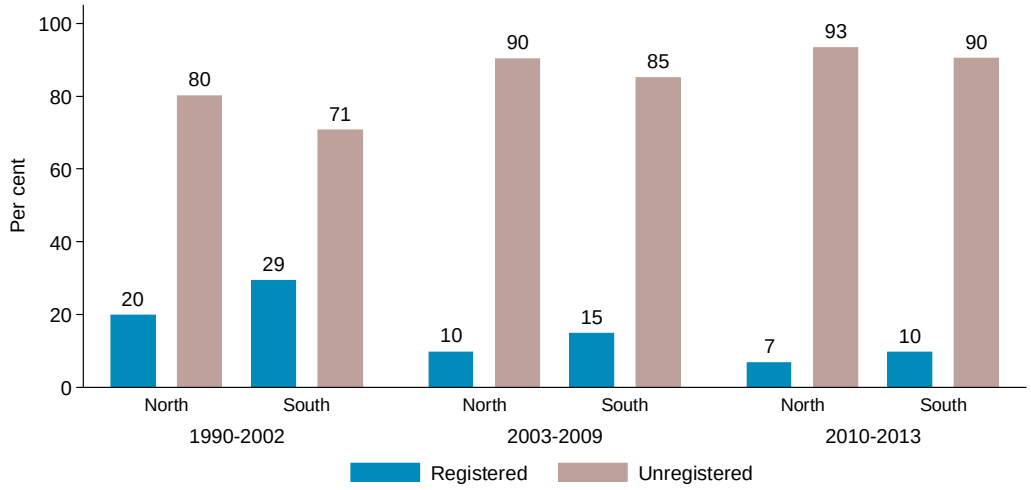
The rate of informality along the extensive margin in WRT services and other services increased in both the south and the north of Ghana, although the magnitude of the change in services in the south and the north was much larger than in manufacturing. For instance, nearly 30 per cent of firms in WRT services created between 1990 and 2002 were registered, which dropped to only 10 per cent for the newer cohort of firms in WRT services born between 2010 and 2013. Similarly, 42 per cent of firms in other services born between 1990 and 2002 were registered; the rate of registration dropped to 13 per cent among firms that entered between 2010 and 2013. The results suggest a positive correlation between the rate of informality along the extensive margin and the subsequent phases of mining development, which appears to be slightly stronger in the south than in the north of Ghana.

Figure 5: Distribution of firms by registration status, within geography, and year of commencement

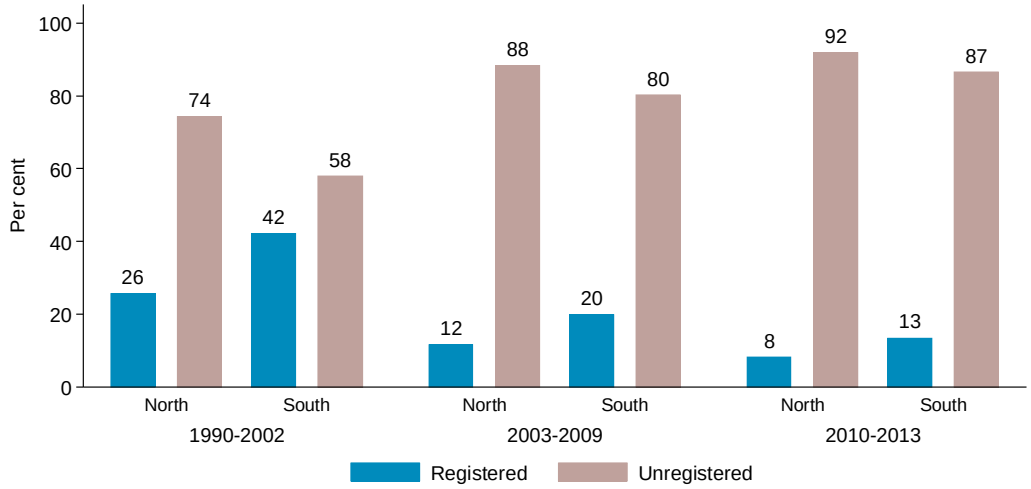
(a) Manufacturing



(b) WRT services



(c) Other services



Note: registered firm refers to a firm registered with the Registrar General's Department.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

Turning to the rate of informality along the intensive margin, the practice of informal account-keeping among newer registered firms is more prevalent, especially in manufacturing and WRT services. In the south of Ghana, the rate of informality along the intensive margin among newer manufacturing firms is higher by 36 percentage points (from 43 per cent in the 1990–2002 cohort to 79 per cent in the 2010–13 cohort). In the north, the rate of informality along the intensive margin among newer manufacturing firms is higher by 32 percentage points (from 56 per cent in the 1990–2002 cohort to 88 per cent in the 2010–13 cohort). Similar to manufacturing firms, we find the gap in the rate of informality along the intensive margin among firms in WRT services to be larger in the south than in the north of the country. In contrast, the magnitude of the increase in the rate of informality along the intensive margin among other services is lower than that in manufacturing and WRT services.

To summarize, the rate of informality along the intensive margin has become larger than the rate of informality along the extensive margin across the subsequent stages of mining growth. Overall, the action along the intensive and extensive margins of informality stands out more in the south than in the north, following a stronger mining shock in the south.

3.1 Change in the rate of informality along the extensive margin

In this section, we present regression results for the likelihood of informality along the extensive margin. Assuming that sorting into informality is linked to the firm's birth year, we use year dummies to estimate the change in the likelihood of informality along the extensive margin in each year from 2003 to 2013 against the first phase of mining development (1990–2002) as the omitted year group. Table 3 reports the regression results. In the north, except for a few sector-year cases, the share of registered firms remained mostly unchanged between 2002 and 2009. However, following the start of oil and gas production in 2010, the rate of registration dropped significantly only in the service sector. Turning to the south of the country, we find results that are similar to those in the north except for some specific years during which the likelihood of informality along the extensive margin became significantly higher than the base period in the light manufacturing (in 2012) and heavy manufacturing (in 2013) sectors.

A comparison of the estimated coefficients of the year dummies across Phase 2 and Phase 3 provides causal evidence of the effects of the phases of mining development on the rate of informality along the extensive margin. Especially in WRT services and other services, the positive and statistically significant coefficients suggest that a higher share of unregistered firms were born since the beginning of oil and gas production. However, we do not find such evidence for manufacturing.

Table 3: Correlates of the likelihood of unregistered firms (the likelihood of informality along the extensive margin)

		Light manufacturing	Heavy manufacturing	WRT services	Other services
		(1)	(2)	(3)	(4)
North					
Phase 2 (2003–09)	2003	0.055	0.135	0.081**	−0.039
		(0.048)	(0.104)	(0.037)	(0.072)
	2004	0.090*	0.083	−0.033	−0.037
		(0.047)	(0.101)	(0.054)	(0.059)
	2005	0.017	0.109	0.019	0.050
		(0.031)	(0.070)	(0.033)	(0.045)
	2006	−0.034	0.156**	−0.023	0.030
		(0.051)	(0.076)	(0.063)	(0.041)
	2007	0.032	0.150*	−0.018	0.013
		(0.046)	(0.083)	(0.041)	(0.054)
	2008	0.021	0.136**	0.040	−0.026
		(0.053)	(0.056)	(0.032)	(0.042)
Phase 3 (2010–13)	2009	−0.036	0.002	0.030	0.125***
		(0.034)	(0.074)	(0.029)	(0.033)
	2010	0.028	0.017	0.087***	0.074**
		(0.039)	(0.061)	(0.027)	(0.037)
	2011	0.027	0.040	0.041	0.099***
		(0.021)	(0.062)	(0.025)	(0.027)
	2012	−0.005	0.081	0.074**	0.097***
		(0.042)	(0.050)	(0.032)	(0.030)
	2013	0.044	0.046	0.087***	0.048
		(0.037)	(0.048)	(0.028)	(0.030)
Constant		0.849***	0.793***	0.781***	0.679***
		(0.020)	(0.023)	(0.015)	(0.017)
N		1,562	498	2,448	2,249
R^2 statistic		0.106	0.135	0.080	0.078

		(5)	(6)	(7)	(8)
South					
Phase 2 (2003–09)	2003	0.109**	0.026	0.024	0.050
		(0.041)	(0.075)	(0.037)	(0.038)
	2004	−0.098**	−0.095	−0.045	−0.099***
		(0.043)	(0.080)	(0.055)	(0.036)
	2005	0.039	0.001	0.064	0.122***
		(0.047)	(0.052)	(0.061)	(0.038)
	2006	0.016	−0.213**	0.036	0.095
		(0.049)	(0.081)	(0.048)	(0.058)
	2007	−0.000	0.007	0.094***	0.035
		(0.050)	(0.074)	(0.033)	(0.032)
	2008	0.022	−0.018	0.047	0.025
		(0.031)	(0.090)	(0.063)	(0.032)
Phase 3 (2010–13)	2009	0.065*	0.033	−0.002	0.097**
		(0.036)	(0.048)	(0.045)	(0.039)
	2010	0.016	0.049	0.062	0.092***
		(0.038)	(0.050)	(0.040)	(0.021)
	2011	−0.006	−0.001	0.028	0.097***
		(0.043)	(0.074)	(0.037)	(0.031)
	2012	0.081**	−0.032	0.121***	0.112***
		(0.037)	(0.048)	(0.025)	(0.022)
	2013	−0.024	0.098**	0.109***	0.128***
		(0.035)	(0.049)	(0.022)	(0.026)
Constant		0.708***	0.637***	0.625***	0.446***
		(0.016)	(0.025)	(0.021)	(0.016)
N		2,134	945	2,917	4,532
R^2 statistic		0.144	0.302	0.171	0.228

Note*:* the dependent variable is registration with Registrar General's Department. Each regression model includes district fixed effects. Standard errors are reported in parentheses. Significance level: *10 per cent, **5 per cent, ***1 per cent.

Source*:* authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

3.2 Change in the rate of informality along the intensive margin

We next present regression results for the likelihood of informality along the intensive margin. Table 4 presents regression results that are based on the sample of registered firms. The regression results for the likelihood of informality along the intensive margin are more heterogeneous than those for the likelihood of informality along the extensive margin. In the north, after the consolidation of large-scale gold mining, the practice of informal account-keeping among registered firms increased only in heavy manufacturing. Among newly registered firms in WRT services, the practice of informal account-keeping has decreased since oil and gas production started in 2010. In the south of Ghana, we find a much stronger increase in the practice of informal account-keeping among newer heavy manufacturing firms and firms in WRT services born after 2010 (Figure 6).

Overall, regression results for the likelihood of informality along the extensive and intensive margins show the strong presence of regional and sectoral differences. We find a strong positive effect of oil and gas production on the rate of informality along the extensive margin in services in the south. At the same time, the likelihood of informality along the intensive margin has increased among younger heavy manufacturing firms and firms in WRT services since oil and gas production started in 2010 in the south.

Table 4: Correlates of the likelihood of informal account-keeping for registered firms (the likelihood of informality along the intensive margin)

		Light manufacturing	Heavy manufacturing	WRT services	Other services
		(1)	(2)	(3)	(4)
North					
Phase 2 (2003–09)	2003	−0.040		0.127	−0.078
		(0.204)		(0.087)	(0.094)
	2004	−0.015	0.108	−0.001	−0.012
		(0.403)	(0.116)	(0.211)	(0.086)
	2005	0.121	0.355**	−0.032	0.036
		(0.173)	(0.126)	(0.095)	(0.091)
	2006	−0.256*	1.000***	−0.293**	−0.001
		(0.146)	(0.000)	(0.137)	(0.090)
	2007	0.402***	0.330	−0.008	0.001
		(0.138)	(0.438)	(0.136)	(0.096)
	2008	−0.074	0.423**	−0.066	−0.213***
		(0.145)	(0.145)	(0.091)	(0.063)
Phase 3 (2010–13)	2009	0.216*	0.216	−0.102	−0.013
		(0.126)	(0.232)	(0.083)	(0.067)
	2010	−0.001	−0.040	−0.181***	0.126
		(0.169)	(0.180)	(0.062)	(0.097)
	2011	−0.132	0.255	−0.077	−0.024
		(0.123)	(0.293)	(0.094)	(0.062)
	2012	−0.108	−0.019	−0.186***	−0.036
		(0.101)	(0.301)	(0.058)	(0.068)
	2013	0.147	0.178	−0.132	0.034
		(0.126)	(0.190)	(0.092)	(0.067)
Constant		0.565***	0.440***	0.587***	0.376***
		(0.056)	(0.060)	(0.025)	(0.031)
N		205	63	425	619
R^2 statistic		0.320	0.369	0.198	0.137
		(5)	(6)	(7)	(8)
South					
Phase 2 (2003–09)	2003	−0.035	−0.180	0.019	−0.030
		(0.105)	(0.199)	(0.051)	(0.044)
	2004	0.090	0.195***	−0.028	−0.111***
		(0.127)	(0.046)	(0.052)	(0.034)
	2005	0.274***	−0.042	0.022	0.035
		(0.047)	(0.112)	(0.090)	(0.052)
	2006	0.130	0.123	0.018	0.047
		(0.116)	(0.089)	(0.062)	(0.040)
	2007	0.095	0.025	0.111	−0.038
		(0.062)	(0.109)	(0.092)	(0.037)
	2008	0.112*	−0.138	0.176***	−0.081***
		(0.056)	(0.104)	(0.060)	(0.022)
Phase 3 (2010–13)	2009	0.056	0.009	0.023	0.010
		(0.087)	(0.099)	(0.080)	(0.045)
	2010	0.132*	0.225**	0.139**	0.017
		(0.073)	(0.089)	(0.065)	(0.029)
	2011	−0.032	0.170**	0.107*	0.051
		(0.082)	(0.079)	(0.056)	(0.044)

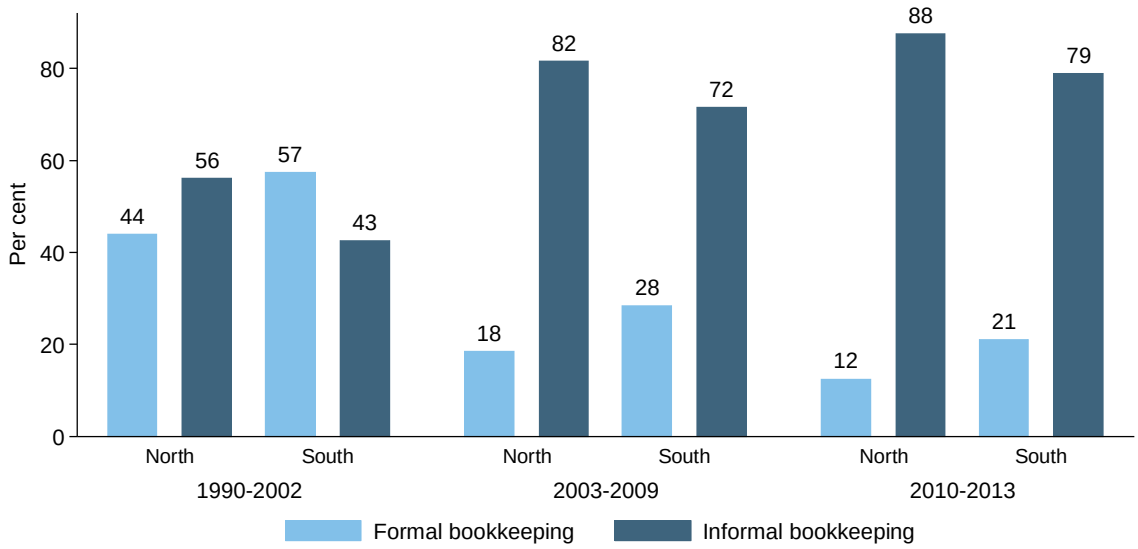
	2012	0.033	0.173**	0.147**	0.050
		(0.060)	(0.068)	(0.065)	(0.039)
	2013	−0.100	0.085	0.143**	0.088*
		(0.087)	(0.135)	(0.063)	(0.045)
Constant		0.382***	0.310***	0.287***	0.287***
		(0.021)	(0.026)	(0.035)	(0.014)
N		581	333	950	2,219
R^2 statistic		0.144	0.225	0.118	0.110

Note: the dependent variable is informal account-keeping. Each regression model includes district fixed effects. Standard errors are reported in parentheses. Significance level: *10 per cent, **5 per cent, ***1 per cent.

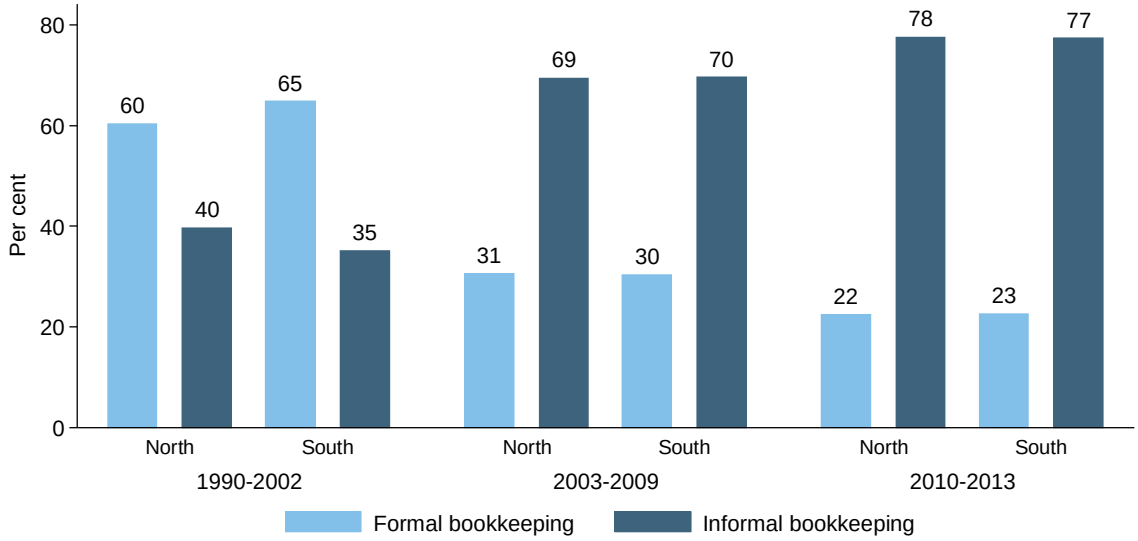
Source*:* authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

Figure 6: Distribution of registered firms by informal account-keeping, within geography, and year of commencement

(a) Manufacturing



(b) WRT services



(c) Other services

Note: registered firm refers to a firm registered with the Registrar General's Department.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

4 Changing pattern of duality between informal and formal firms

We next examine the change in formal–informal duality over the phases of development in mining in Ghana. The competing theoretical frameworks on dualism between informal and formal firms are primarily related to the entry requirements in the formal sector (La Porta and Shleifer 2008, 2014). The survival view refers to informal firms that are too unproductive to become formal. The parasite view refers to informal firms that choose not to enter the formal sector as they find it more profitable to remain in the informal sector. Finally, the De Soto (1989) view defines informal firms as potentially productive firms remaining informal because of the high cost of entering the formal sector. These theoretical frameworks have been interpreted as the main reasons for formal and informal firms to operate in different economic environments, producing different products. Ulyssea (2018) claims that these competing views are complementary and the heterogeneity among informal firms and the regulatory environment they face essentially explains the differences between formal and informal firms. Evidence using Ghanaian data also supports the growing heterogeneity among informal firms, as discussed in Section 3.

For a deeper understanding of the changing pattern of the formal–informal duality, we examine different aspects of the duality. We first present regression results for the productivity gap between formal and informal firms within each stage of mining development. We then discuss regression results for the change in productivity of informal and formal firms across the different stages of mining development. Finally, we discuss the findings on skilled employment and the role of firms sorting into the formal and informal sectors.

4.1 Productivity gap between formal and informal firms

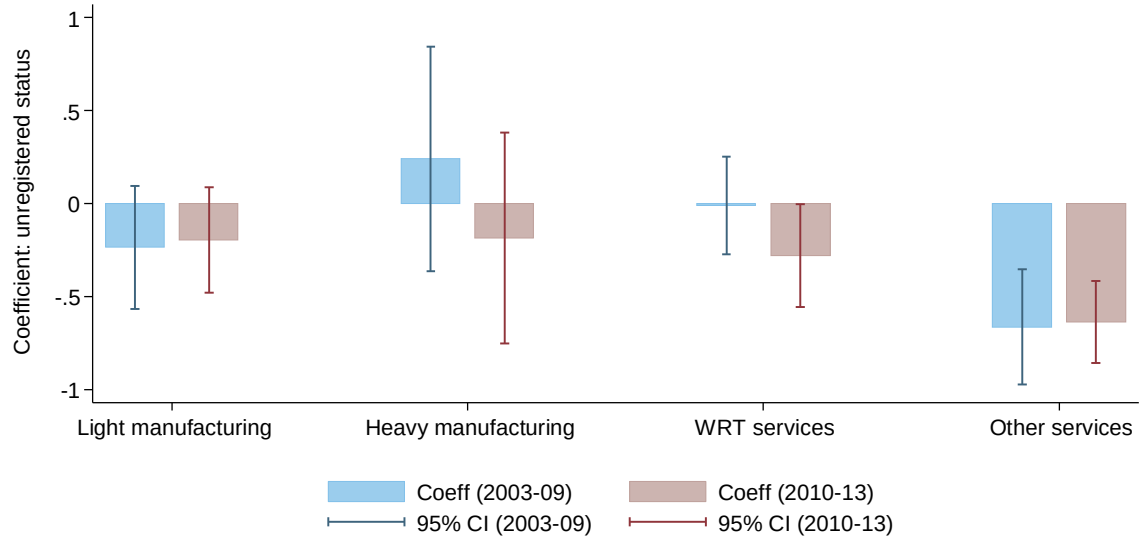
Figure 7 depicts the results of the productivity gap between registered and unregistered firms. A negative coefficient indicates a higher productivity level in registered firms than in unregistered firms. We find mixed evidence on the formal–informal productivity gap. In both the south and the north, registered firms are more productive than unregistered firms in the service sector within

each birth cohort of firms (2003–09 and 2010–13). In contrast, unregistered firms born between 2003 and 2009 appear to be more productive than registered firms born in the same period in heavy manufacturing in both the south and the north. In the birth cohort following the start of oil and gas production in 2010, unregistered heavy manufacturing firms are more productive than registered heavy manufacturing firms in the south. The formal–informal productivity gap for light manufacturing firms appears smaller than that in other sectors.

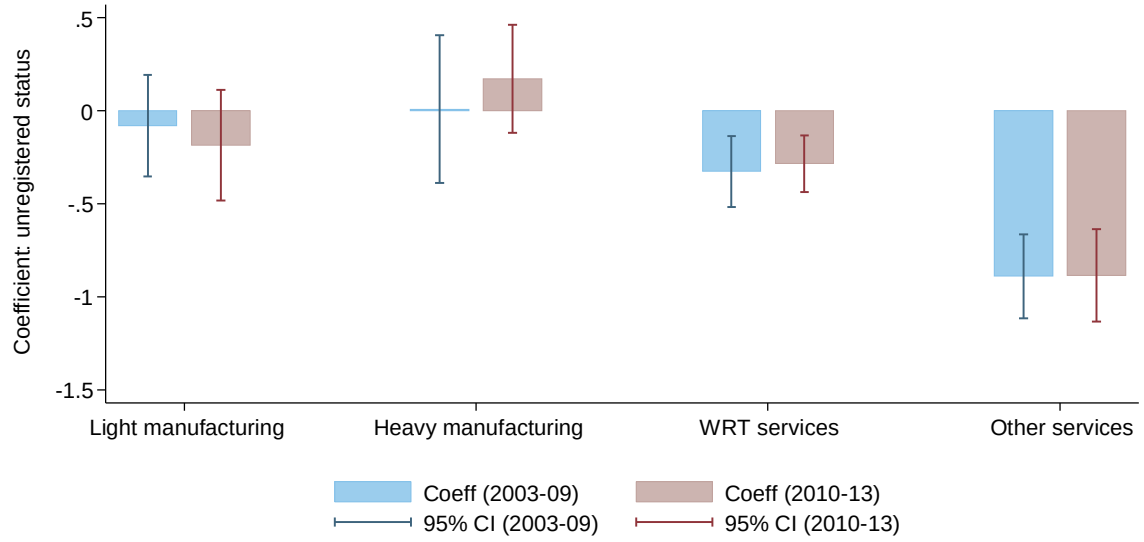
Overall, the findings suggest that heavy manufacturing is the only sector in which firm registration does not necessarily return a higher level of productivity.

Figure 7: Productivity gap between registered and unregistered firms, within the phases of mining development

(a) North



(b) South



Note: Coeff, coefficient; CI, confidence interval. Registered firm refers to a firm registered with the Registrar General's Department.

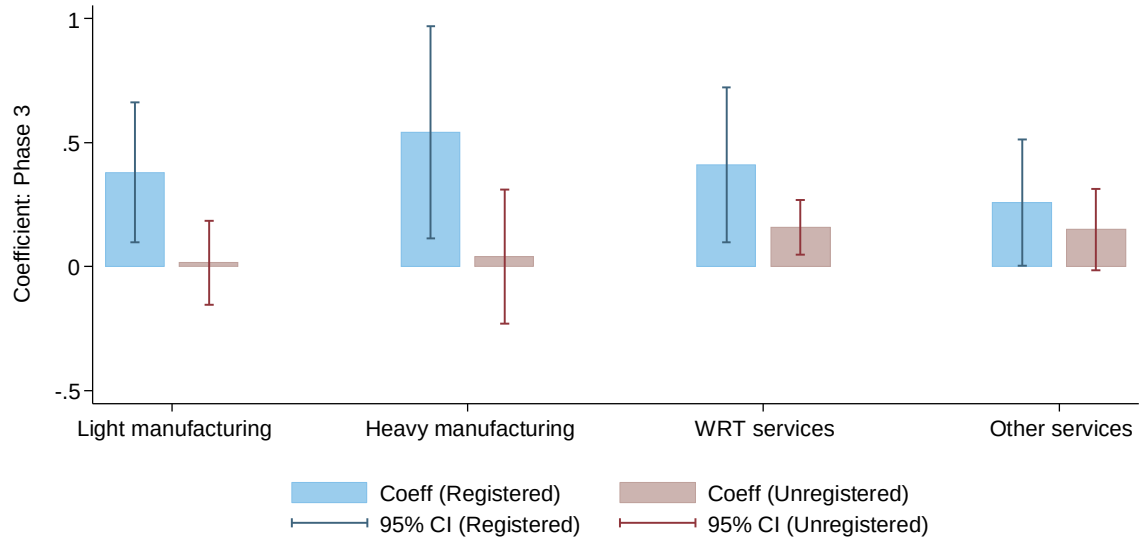
Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

4.2 Productivity gap within formal and informal firms

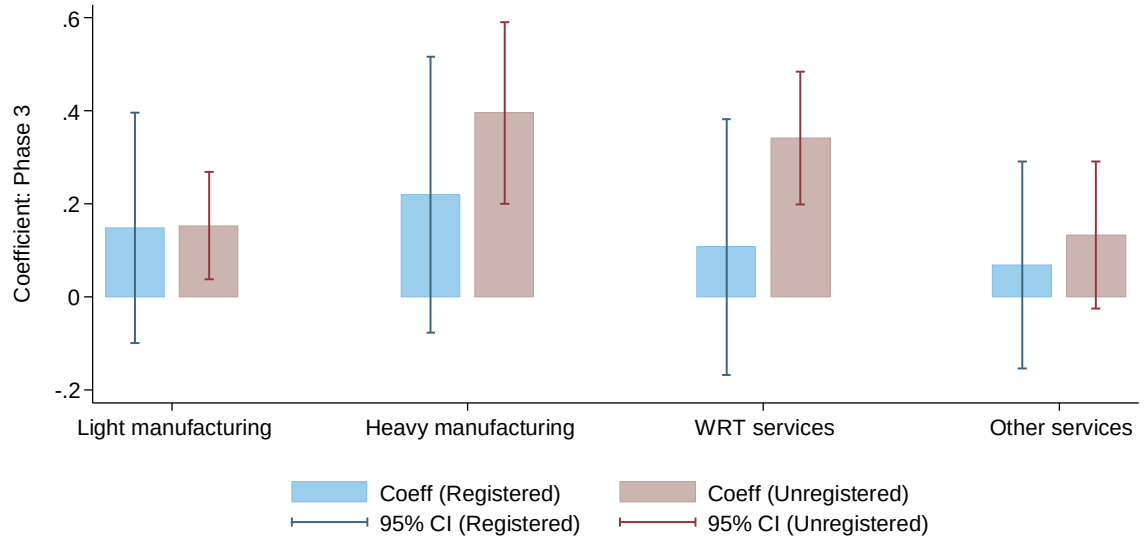
In Figure 8, we plot regression results for the productivity gap between different birth cohorts within registered and unregistered firms. The productivity of younger firms born after 2010 is higher than that of older firms across the board. In the north, the productivity gap is larger and more statistically significant for registered firms than for unregistered firms. We find the opposite result in the south. The productivity gap between older and newer firms is much larger for unregistered firms than for registered firms in all sectors except other services. Since the mining shock occurred primarily in the south of Ghana, these results suggest that mining played a role in creating equal opportunities for formal and informal firms.

Figure 8: Productivity gap between the phases of mining development, within registered and unregistered firms

(a) North



(b) South



Note: Coeff, coefficient; CI, confidence interval. Registered firm refers to a firm registered with the Registrar General's Department. Phase 3 = 1 if 2010–13, 0 otherwise.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

The positive mining shock created a level playing field for informal and formal firms, which is in line with the growing evidence on the lack of the duality in technology, products, and operational procedures between informal and formal firms (Allen et al. 2018; Meghir et al. 2015; Ulyssea 2018).

4.3 Change in the level of skilled employment

Next, we discuss regression results for the change in the level of skilled employment. Table 5 reports the regression results for skilled employment. Similar to the results for the likelihood of informality along the extensive and intensive margins, we find considerable heterogeneity in the results for skilled employment across sectors and regions. In the north, the share of skilled employment in younger firms born after 2010 is higher than the share in older firms across all sectors (Panel B, Table 5). The results are different in the south except for firms in other services.

Panel B in Table 5 compares the skilled employment share between registered and unregistered firms. In the north, the share of skilled employment is higher in unregistered firms than in registered firms for light manufacturing and other services. In the south, similar results hold for light and heavy manufacturing. The share of skilled employment is lower for registered firms with informal account-keeping than for registered firms with formal account-keeping in all sectors except heavy manufacturing. Heavy manufacturing is the only sector in the south in which both types of informality are correlated with a higher share of skilled employment and a higher level of productivity.

4.4 Role of sorting

The results on the formal–informal duality presented in the previous sections were based on the likelihood of informality along the extensive and intensive margins, productivity, and skilled employment of firms observed only for 2013. The productivity growth within a firm can also account for a substantial part of the change in the pattern of formal–informal dualism; if this process is independent of the mining shocks, then it can invalidate the empirical support for the role of mining in the change in the formal–informal duality. Due to data constraints, it is not feasible to track the change in productivity within a firm over time and the transitions between the informal and formal sectors.

As a second-best strategy, we examine the role of firms sorting into formality. The productivity gap between informal and formal firms could also arise from firms sorting into both sectors based on productivity at the time of entry (Ulyssea 2018). Using our data, we can estimate productivity at the time of entry for the youngest firms born in 2013. As shown in Figure 9d, the density plots of productivity (measured as sales per employee) and the size of firms (measured as log revenue) among registered and unregistered heavy manufacturing firms overlap to a large extent. As such, the firms sorting into the formal and informal sectors at the time of entry appear negligible in terms of both productivity and size.[9] Since the youngest firms were established after 2010, it is possible that mining has played some role in creating this level playing field.

[9] The sorting into informal and formal firms based on productivity becomes more obvious when we consider the full sample of firms (Appendix Figure A1).

Table 5: Correlates of the skilled employment share

	North				South			
	Light manufacturing	Heavy manufacturing	WRT services	Other services	Light manufacturing	Heavy manufacturing	WRT services	Other services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A								
Phase (=1 if 2003–09, =0 otherwise)	0.014	0.013	−0.017	0.029*	0.005	0.012	−0.010	0.050***
	(0.010)	(0.032)	(0.016)	(0.017)	(0.012)	(0.022)	(0.018)	(0.018)
Phase (=1 if 2010–13, =0 otherwise)	0.031***	0.040*	0.010	0.057***	0.015	−0.030	−0.017	0.053***
	(0.011)	(0.021)	(0.017)	(0.017)	(0.014)	(0.022)	(0.020)	(0.020)
Constant	0.906***	0.907***	0.838***	0.830***	0.887***	0.895***	0.794***	0.807***
	(0.007)	(0.016)	(0.011)	(0.011)	(0.008)	(0.015)	(0.013)	(0.013)
N	1,562	498	2,448	2,249	2,134	945	2,917	4,532
R^2 statistic	0.115	0.110	0.120	0.140	0.081	0.072	0.131	0.089
Panel B								
Unregistered	0.074***	−0.007	0.005	0.033**	0.070***	0.068***	−0.063***	0.000
	(0.022)	(0.031)	(0.016)	(0.013)	(0.020)	(0.023)	(0.021)	(0.019)
Constant	0.859***	0.933***	0.833***	0.840***	0.843***	0.845***	0.827***	0.846***
	(0.019)	(0.026)	(0.013)	(0.009)	(0.014)	(0.015)	(0.014)	(0.010)
N	1,562	498	2,448	2,249	2,134	945	2,917	4,532
R^2 statistic	0.125	0.104	0.118	0.136	0.095	0.080	0.137	0.083
Panel C								
No formal account	−0.057*	−0.020	−0.160***	−0.039**	−0.037	0.059***	−0.102**	−0.080***
	(0.030)	(0.012)	(0.057)	(0.018)	(0.024)	(0.019)	(0.045)	(0.015)
Constant	0.909***	0.955***	0.917***	0.864***	0.874***	0.830***	0.881***	0.888***
	(0.018)	(0.007)	(0.029)	(0.007)	(0.010)	(0.007)	(0.016)	(0.005)
N	205	63	425	619	581	333	950	2,219
R^2 statistic	0.268	0.197	0.219	0.164	0.184	0.114	0.140	0.139

Note: the dependent variable is the skilled employment share in August 2014. Standard errors are reported in parentheses. Significance level: *10 per cent, **5 per cent, ***1 per cent.

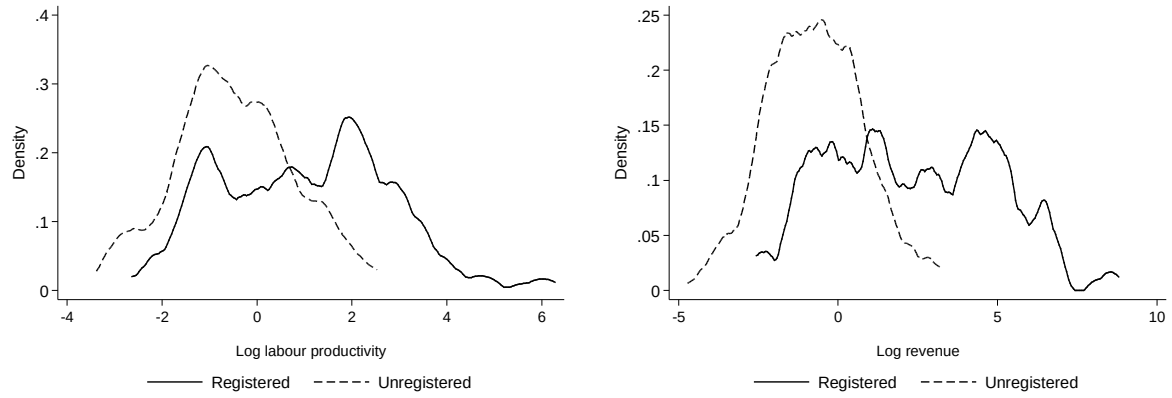
Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

If we assume that firms sorting into different sectors takes place only at the time of entry, then the difference in the role of sorting between the youngest and older heavy manufacturing firms can possibly be attributed to mining. The overlap between the density plots of productivity between registered and unregistered firms is lower for older heavy manufacturing firms (Figure 9a–9c) than for the youngest heavy manufacturing firms (Figure 9d). The large gaps in the productivity and size distributions between registered and unregistered older (established before 2010) heavy manufacturing firms suggest a stronger incidence of firms sorting into different sectors before the start of oil and gas production. However, this must be interpreted cautiously as we assume that sorting into different sectors takes place only at the time of entry and, as such, firms do not switch between informal and formal sectors after establishment. Without the knowledge of whether firms switched back and forth between the formal and informal sectors, it is difficult to conclude whether within-firm productivity growth was completely independent of the mining productivity shocks. Nevertheless, the consistent pattern of sorting across firm birth cohorts suggests that the mining shocks played a role in the lack of formal–informal duality.

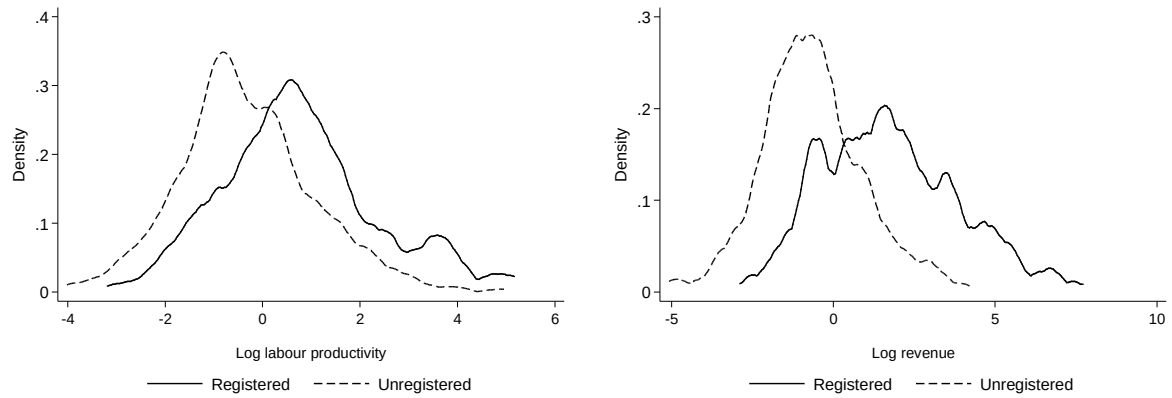
Therefore, the evidence suggests that the mining productivity shocks may have played a role in the heterogeneity in productivity both within and between informal and formal firms. Younger firms that were established after the start of oil and gas production in 2010 are more productive in heavy manufacturing than in other sectors. This is supported by the higher level of productivity and higher share of skilled employment in unregistered heavy manufacturing firms than in registered heavy manufacturing firms. Finally, it appears that there was less sorting of firms into the formal and informal sectors after the start of oil and gas production in 2010, and this corroborates the lack of duality between informal and formal firms.

Figure 9: Productivity and size, new entrants versus older firms in heavy manufacturing

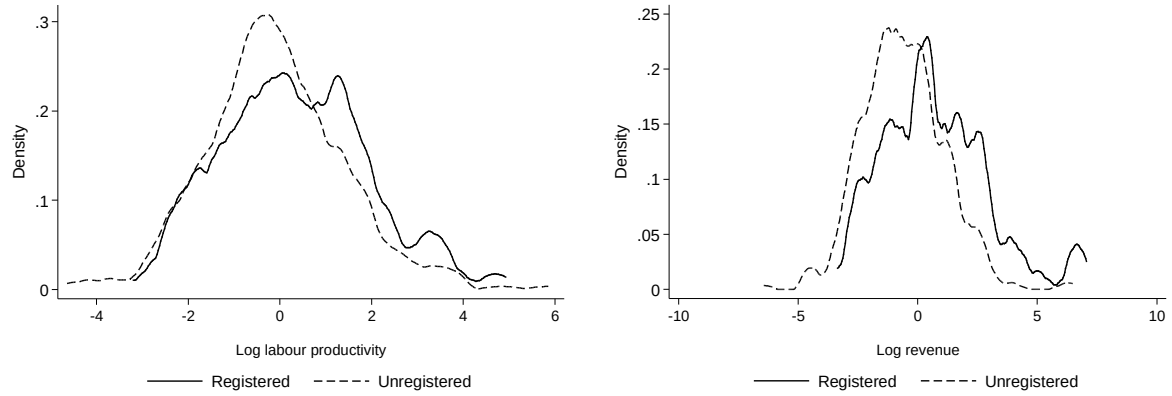
(a) 1990–2002 cohort



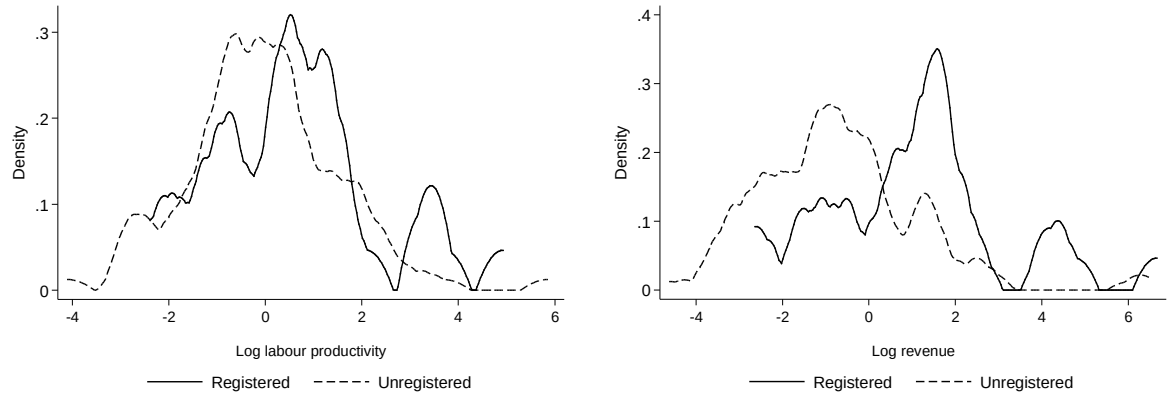
(b) 2003–09 cohort



(c) 2010–13 cohort



(d) 2013 cohort



Note: Epanechnikov kernel plots with bandwidth = 0.25.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

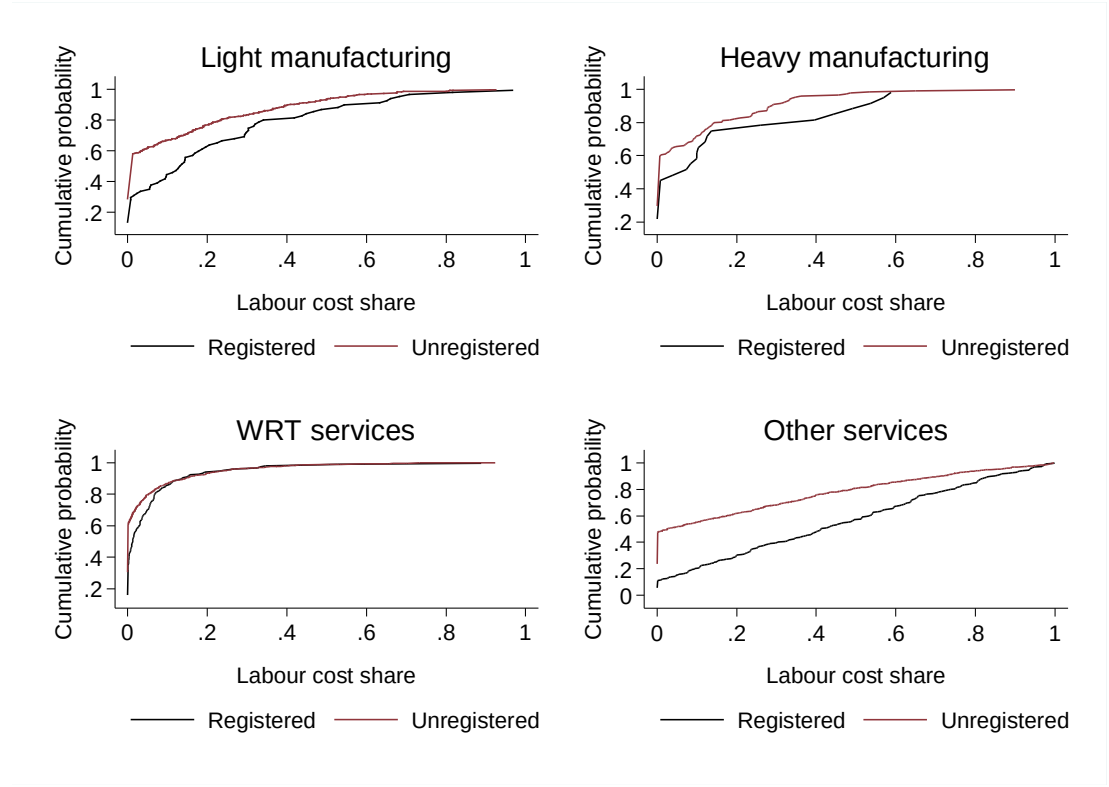
5 Mechanisms: factor input cost shares

In Sections 3 and 4, we presented results that are suggestive of a stronger link between mining development and changes in the rates of informality along the extensive and intensive margins and the changing pattern of the formal–informal duality in manufacturing and services in Ghana. In this section, we investigate further to understand the possible mechanisms of how mining productivity shocks make informal firms more productive than formal firms in heavy manufacturing.

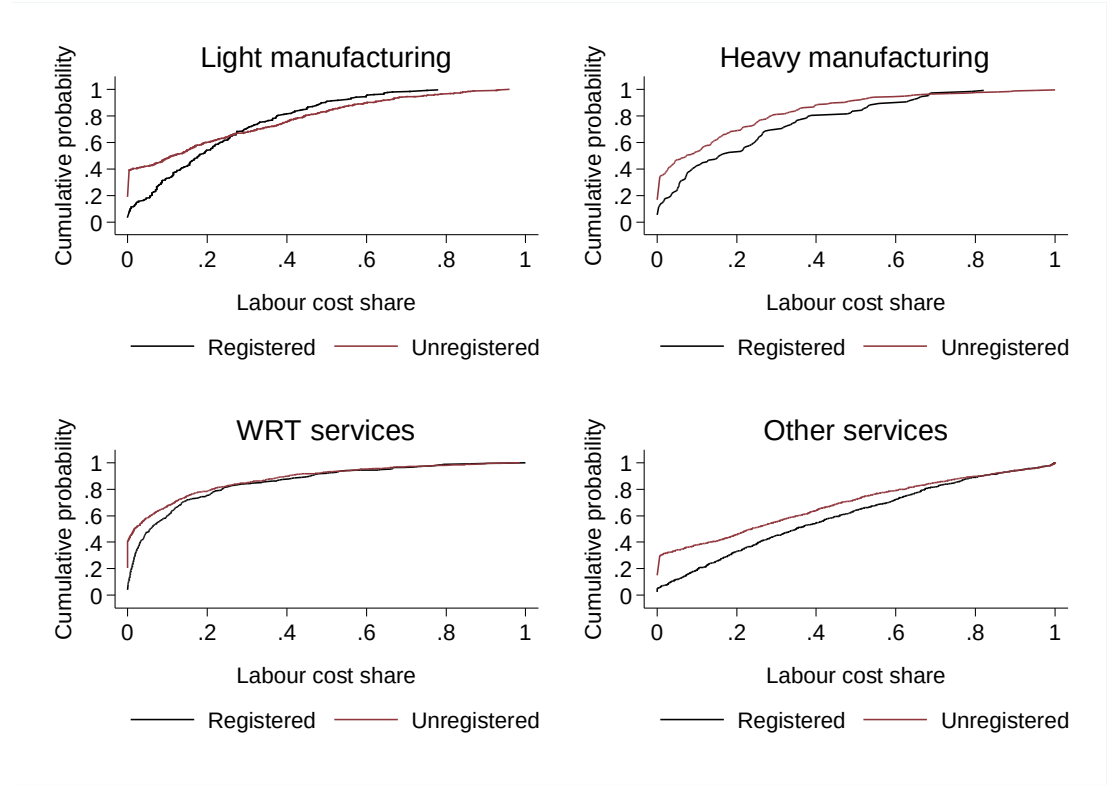
We hypothesize that because of the growth in the mining sector, the factor cost share in informal firms becomes lower than in formal firms. We compute the labour, material, and fuel cost shares as the proportion of the total cost of goods supplied for younger firms born after oil and gas production started in 2010. Figure 10 compares the cumulative distribution of the labour cost share between registered and unregistered firms across sectors. In the north, the distribution of the labour cost share of registered firms first-order stochastically dominates that of unregistered firms in all sectors except WRT services. In the south, similar evidence holds only for heavy manufacturing and other services. Unregistered heavy manufacturing firms that appear more productive also incur a lower labour cost share than registered heavy manufacturing firms in the south. This is consistent with the increase in the rate of informality along the intensive margin among registered firms as they try to compete with their unregistered counterparts in heavy manufacturing since oil and gas production started in 2010 in the south.

Figure 10: Cumulative distribution of the labour cost share of firms that commenced after 2010 by registration status, geography, and sector

(a) North



(b) South



Note: labour cost share is defined as the proportion of labour cost to the cost of goods supplied.

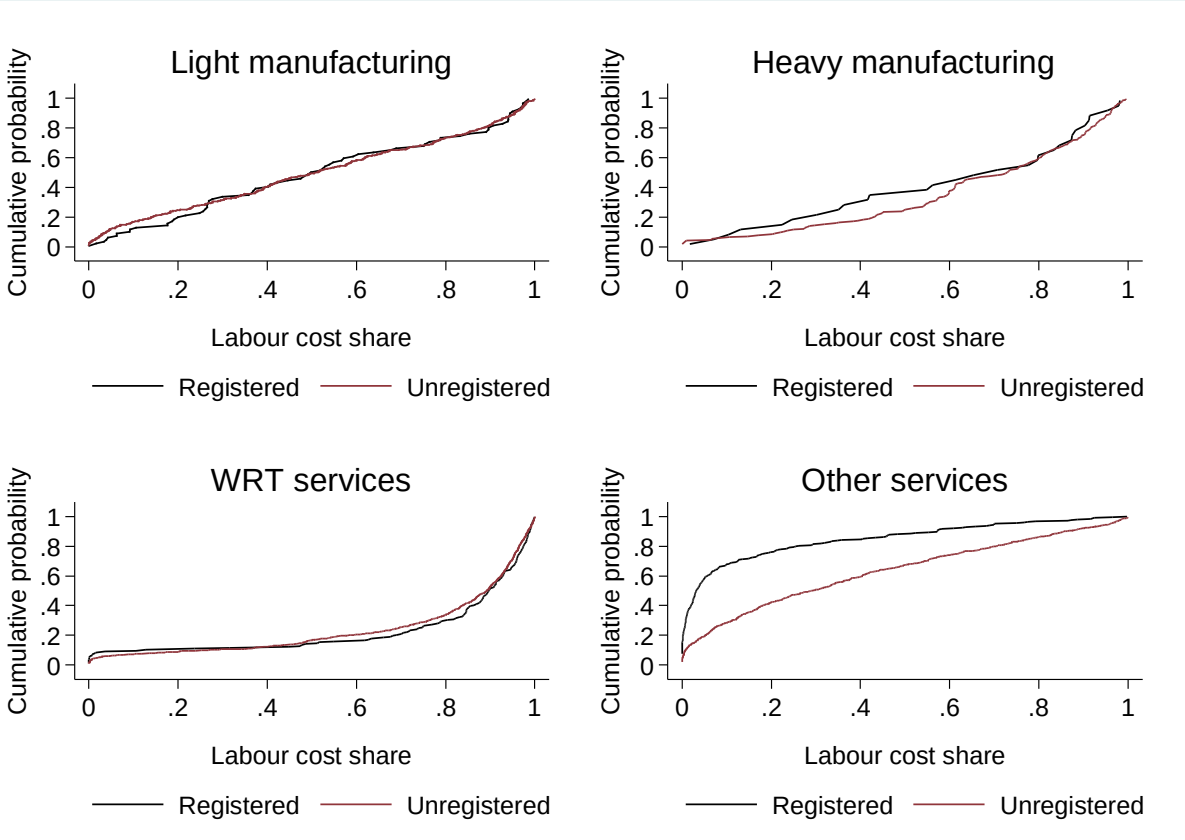
Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

The distribution of the material cost share of unregistered firms first-order stochastically dominates that of registered firms in other services in both the south and the north (Figure 11). Similar findings for heavy manufacturing firms hold only in the south (Figure 11b). For light manufacturing and WRT services, we do not find any difference in the distribution of material cost share between registered and unregistered firms. In terms of material costs, unregistered heavy manufacturing firms are clearly not in an advantageous position compared with registered heavy manufacturing firms. In Figure 12, we plot the cumulative distribution of the fuel cost share between registered and unregistered firms across sectors. In the north, the fuel cost share of registered firms first-order stochastically dominates that of unregistered firms only in other services. In contrast, Figure 12b suggests that the fuel cost share of registered firms first-order stochastically dominates that of unregistered firms across all sectors in the south.

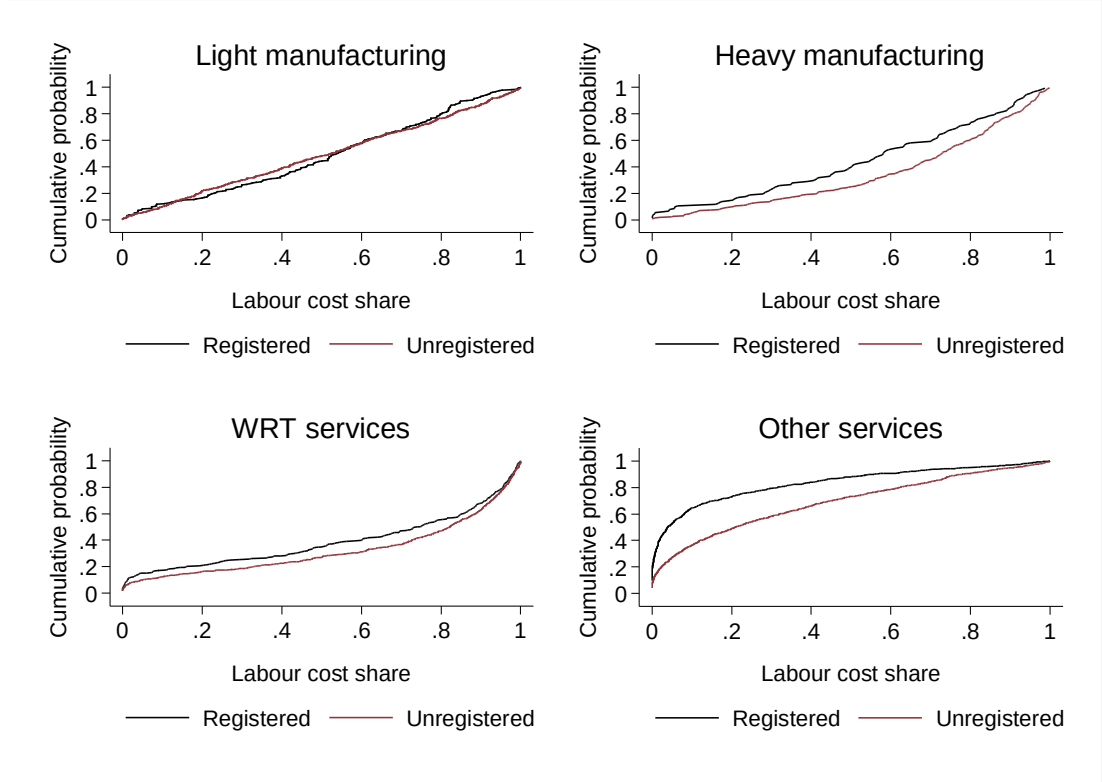
Overall, the findings from the density plots of factor cost shares provide additional insights into the lack of duality between informal and formal firms. In most cases, the distributions of the factor input cost shares between younger registered and younger unregistered firms overlap, and as such the input cost share does not differ by a large margin between informal and formal firms. In heavy manufacturing, unregistered firms clearly enjoy lower labour and fuel costs but incur a higher material cost than registered firms.

Figure 11: Cumulative distribution of the material cost share of firms that commenced after 2010 by registration status, geography, and sector

(a) North



(b) South

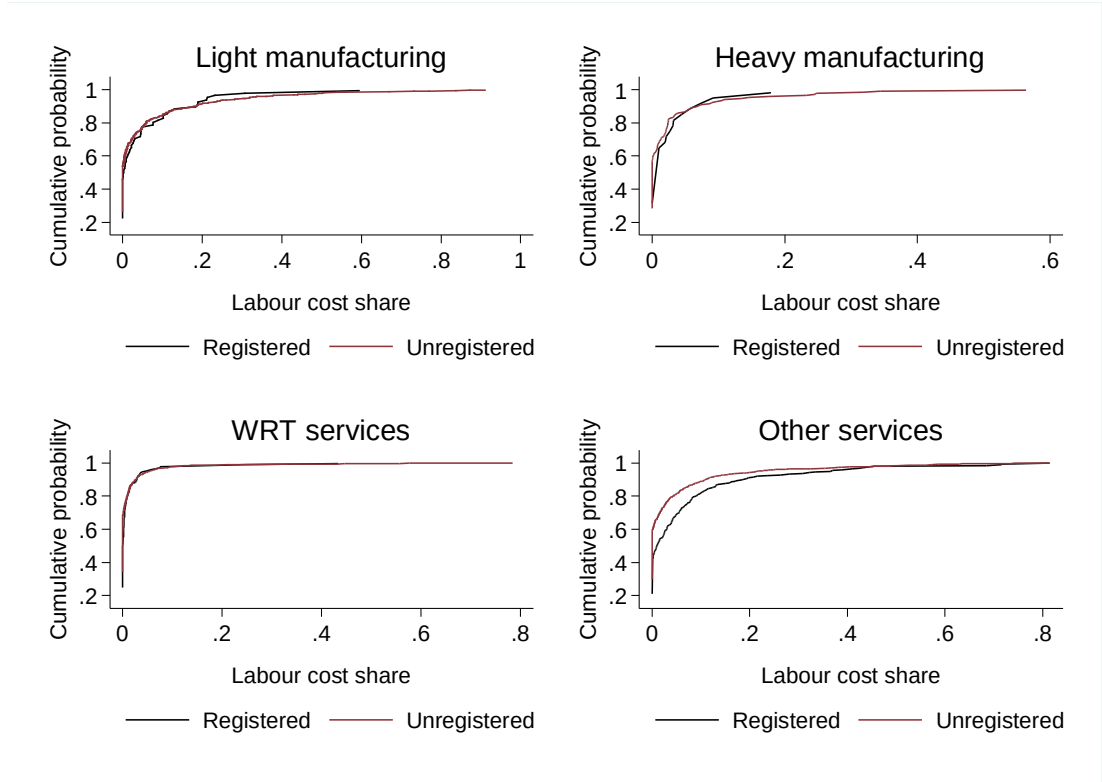


Note: material cost share is defined as the proportion of material cost to the cost of goods supplied.

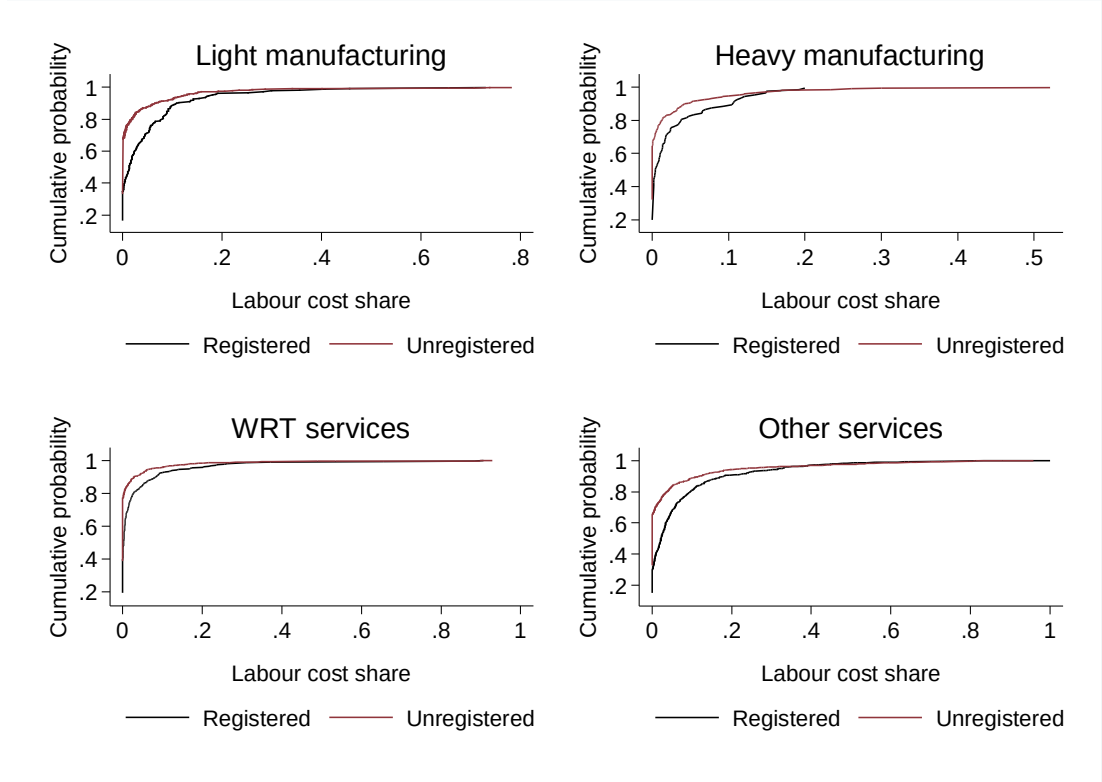
Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

Figure 12: Cumulative distribution of the fuel cost share of firms that commenced after 2010 by registration status, geography, and sector

(a) North



(b) South



Note: fuel cost share is defined as the proportion of fuel cost to the cost of goods supplied.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).

6 Conclusion

In many low-income countries, including Ghana, weak governance and high natural resource dependency create challenges for transforming an exogenous shock in mineral production into job creation and aggregate productivity growth (Coulibaly et al. 2022; Mehlum et al. 2006; Sachs and Warner 2001). The presence of widespread informality makes this task more difficult since informal firms tend to be less productive than formal firms, as documented by a large body of literature on formal–informal duality. In this study, we took a different stance. Exploiting two exogenous mining shocks—the beginning of large-scale gold production in 2003 and the start of oil and gas production in 2010 in Ghana—our goal was to understand whether the mining productivity shocks produced a level playing field and, consequently, reduced the extent of duality between formal and informal firms in manufacturing and services.

Using 2014 Ghanaian firm census data, we measured the rates of informality along the extensive (unregistered firms) and intensive (registered firms hiring labourers 'off the books') margins and found that they responded differently to the mining productivity shocks across sectors. Our results point to the possible roles that mining productivity shocks played in the heterogeneity in productivity within as well as between informal and formal firms. The lack of formal–informal duality was most noticeable among heavy manufacturing firms established after 2010, driven by the higher level of productivity in unregistered heavy manufacturing firms than in registered heavy manufacturing firms. Unregistered firms also enjoyed lower labour and fuel costs, but they incurred a higher material cost than registered firms in heavy manufacturing. Finally, there appears

to have been less sorting of firms into the formal and informal sectors since oil and gas production started in 2010, which also contributed to the lack of duality between informal and formal firms.

Our findings are largely in line with the existing literature documenting the lack of duality between informal and formal firms. We add to this literature by providing evidence of the role of mining productivity shocks. A fruitful extension of the current study would be to examine firms that were born alike but followed different trajectories of formality and informality in the presence of such exogeneous sectoral productivity shocks. In addition, modelling the interaction between informality along the extensive and intensive margins as performed by Ulyssea (2018) but extending it in the context of an exogenous shock could capture the dynamics of the formal–informal duality.

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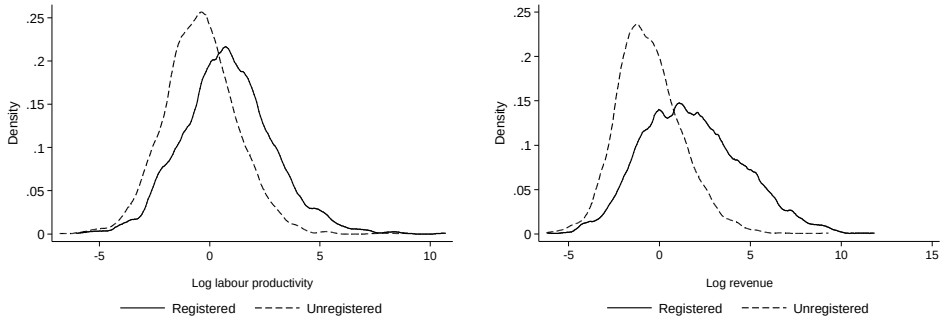
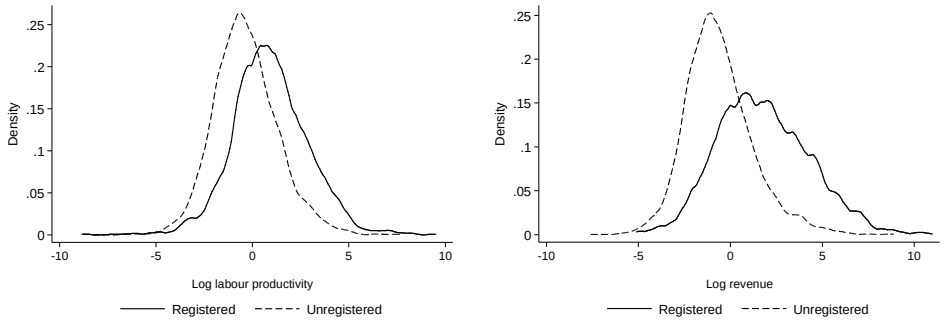
Appendix A

Figure A1: Productivity and size, new entrants versus older firms (all firms)

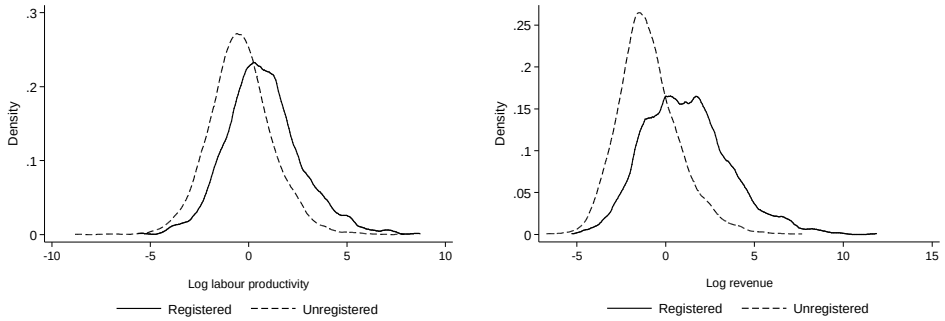
(a) 1990–2002 cohort



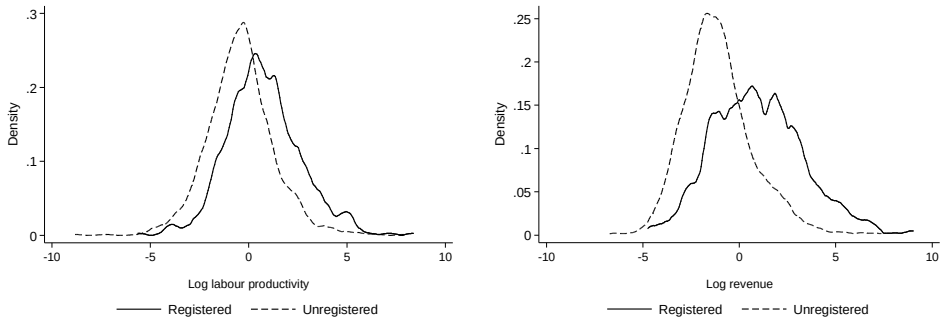
(b) 2003–09 cohort



(c) 2010–13 cohort



(d) 2013 cohort



Note: Epanechnikov kernel plots with bandwidth = 0.25. Following Ulyssea (2018), to obtain a cleaner measure, we regress log productivity and log size on four sector dummies to purge inter-sector variation and use log residuals for the kernel density plots.

Source: authors' estimates based on data from the 2014 Integrated Business Establishment Survey (GSS 2016).