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Structural change(s) in Ghana: A comparison between the trade, formal and informal sectors

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Abstract

This paper uses the case of Ghana to unpack the role of the informal sector in the process of structural change. A structuralist view of structural change – framed as changes in the employment shares of different industries – is combined with the insight that countries strive to diversify towards more complex industries in pursuit of economic upgrading. The paper adopts and adapts the product space and complexity analytical frameworks to compare changes in the relative importance of industries across the trade, formal and informal sectors, over a ten-year period starting in 2003. To assess whether the Ghanaian labour force has moved towards more or less complex industries, the changes in relative shares of finely disaggregated industries are assessed against an employment-based industrial complexity index. The results indicate that Ghana's export and formal sectors have moved towards more complex industries, although export specialisation has moved towards export of natural resources. While exports of manufactured goods have increased, employment in formal and informal manufacturing has contracted, although, in the former case, employment has relocated towards more complex manufacturing industries. In contrast, the informal sector has moved towards less complex activities. The results stress on the need to align the productive capabilities of the informal sector with the Ghana's productive structure in order to allow the participation of Ghanaian households to the process of structural transformation.

Keywords: Structural change, industrial complexity, Ghana, employment, informality
JEL Codes: J21, O14, O17, O55

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1   Introduction

Since the mid-1990s, the Sub-Saharan Africa (SSA) countries have experienced substantial rates of GDP growth. However, their economic growth has often been considered jobless, lacking the depth that characterises structural change-driven economic growth (African Center for Economic Transformation, 2014). Several international development organisations (African Center for Economic Transformation, 2014, 2017; International Fund for Agricultural Development, 2019) and academics (Alcorta, Foster-McGregor, Verspagen, & Szirmai, 2021; Arndt, McKay, & Tarp, 2016; Kanbur, Akbar, & Stiglitz, 2019) have proposed different approaches and policies to promote structural transformation and long-term inclusive growth in African economies, emphasising the crucial role of increasing agricultural productivity, encouraging economic diversification and fostering employment creation. However, these objectives have to take into account that the process of structural change in African countries differs from that in other world areas (Bah, 2011) and that their pathways will depend on historical and current national and global economic conditions.

African countries somehow skipped the industrialisation stages of structural change – or prematurely de-industrialised (Rodrik, 2016) – moving directly from agriculture to non-tradable services (McMillan, Rodrik, & Sepúlveda, 2017). Also, their industry baskets are characterised by specialisation in unsophisticated products, limited economic diversification and low productive capabilities (Bhorat, Kanbur, Rooney, & Steenkamp, 2020). This has resulted in reduced employment in manufacturing: as the technological frontier continues to advance, de-industrialisation reduces the ability to accumulate the dynamic capabilities required to catch-up (Vivarelli, 2021).

This paper examines structural change in one African country – Ghana – focusing on the transformation of its export, formal and informal activities to distinguish the underlying drivers of economic performance in the SSA region. Whereas Ghana's economy has grown very rapidly, this has not led to a pattern of structural change based, for instance, on acquisition of technological capabilities. The International Monetary Fund (International Monetary Fund, 2019) considers that Ghanaian GDP growth has outperformed that of most countries in the region. In 2017, its exports accounted for 35 per cent of GDP (World Bank, 2022), well above the average of the SSA (27.3%) and OECD countries (27.8%). While Ghana's GDP growth and exports suggest positive economic performance, this country faces several difficulties related to its productive and employment structure (Osei & Jedwab, 2017). First, the growth acceleration[1] experienced by Ghana between 2008 and 2016 was driven mainly by rising prices of exported commodities[2], especially mining sector goods (African Development Bank, 2019, p. 49), combined with an expansion of services. Also, the primary sector accounts for only a small share of labour in Ghana and its exports are extremely concentrated, with 27 firms responsible for 62 per cent of Ghana's total

exports (Sutton & Kpentey, 2012). In the absence of links with other national industries and firms (Hausmann, Klinger, & Lawrence, 2008; Savona, 2021), specialisation in the export of commodities may not be beneficial for Ghana's structural change (Sachs & Warner, 2001). Second, 28.6 per cent of Ghana's GDP is generated by the informal sector, which is concentrated on low productivity activities, and accounts for for 87 per cent of commercial establishments in Ghana (Ghana Statistical Service, 2015). Thirdly, aggregate (formal and informal) agricultural employment is moving towards services, leaving the share of manufacturing unchanged since the 1960s (World Bank, 2022) and incapable of attracting foreign direct investments (Sutton & Kpentey, 2012). This has been the consequence not of a rural push (increased agricultural productivity), but of an urban pull (Osei & Jedwab, 2017), including the creation of jobs in urban services that has resulted in "urbanisation without industrialisation" (Gollin, Jedwab, & Vollrath, 2016). Also, household surveys (Ghana Statistical Service, 2019) indicate that agriculture is still the predominant source of livelihood for Ghanaian households.

If the lion's share of exported goods is made up by commodities that are poorly linked to the rest of the economy, and if employment has been moving mainly to non-tradable services, the major export sector is not leading to a structural transformation that entails an employment shift from primary to more productive activities such as manufacturing. This situation is exacerbated by the predominance of informal activities. In this context, it is important to identify the determinants of these patterns of structural change in Ghana and what might represent a specialisation trap in the long run. The present study focuses on the export sector, the predominant household informal sector, and the small formal sector, and examines their respective trends and differences. This will provide a grounded empirical context that will give content and dimension to the nature of structural change in one of the most representative countries in SSA.

The analysis compares the changes in the sectoral composition of Ghana's three sectors over a period of approximately 10 years, starting in 2003. The trade sector is measured by exports; the formal sector is measured by aggregating employment data from two firm censuses, the National Industrial Census (2003) and the Integrated Business Establishment Survey (2014); household informal activities are measured using household employment data from the Ghana Living Standards Survey.

In addition to studying changes in the relative shares of each industry, this study assesses the quality of these changes, using the Industry Complexity Index (ICI) – a measure of industry sophistication. The complexity measures have been used widely to proxy for country capabilities to diversify and upgrade their productive structure towards more sophisticated and higher value added industries (Hidalgo & Hausmann, 2009; Tacchella, Cristelli, Caldarelli, Gabrielli, & Pietronero, 2012). It has been argued also that actively pursuing increased complexity of industrial specialisation is an effective strategy for governments to

achieve economic growth, also in Africa (Lin, Cader, & Pietronero, 2020). Traditionally, the complexity measures build on national export specialisation: industries or products that are less ubiquitous (i.e., that require 'rare' capabilities and, therefore, are produced by a small set of countries) and are produced by highly diversified countries or regions (i.e., with diverse stocks of capabilities) are considered more complex. Given the importance of the employment dimension in the analysis of Ghana's structural change, industrial complexity is defined here on the basis of district employment specialisation patterns, which is a variation of the Fitness method proposed by Tacchella et al. (2012), that relies on export specialisation patterns. This employment-based measure of industrial sophistication is combined with information on sectoral changes to assess whether Ghana's employment and productive structures are moving towards more sophisticated and capabilities-intensive industries.

This paper contributes to the literature on the characteristics of structural change in African countries and the extent to which this might lead to long-term and sustainable economic development. Most of these studies have successfully examined the quality of structural change in African economies, in terms of productivity (de Vries, Timmer, & de Vries, 2015; McMillan et al., 2017; McMillan, Rodrik, & Íñigo Verduzco-Gallo, 2014; McMillan & Zeufack, 2022). A focus on industry sophistication (ICI), rather than productivity, makes it possible to measure the quality of industries at a finer level of industry aggregation (4-digit ISIC) and to capture the estimated capabilities within each industry. A focus on the capabilities required by a particular sectoral specialisation, rather than on its productivity, helps to unpack the 'quality' of structural change, in terms not only of its economic performance but also of the inputs required to achieve it, providing a new foundation from which to provide recommendations for industrial policy.

The results show that, between 2003-2013, industry specialisation in Ghana changed in the trade and formal sectors, but not in the household informal sector. Ghana increased its specialisation mainly in the extraction of natural resources, such as oil, which despite their high complexity are not accompanied by significant job creation. In fact, employment creation in downstream oil processing sectors reduced over that period.

There are significant differences, also, between the changes observed in exporting and those observed in total domestic employment. While exports of manufactured products have increased, employment in manufacturing has shrunk in both the formal sector (with respect to mining) and the informal sector (with respect to all industries). However, a part of formal manufacturing employment has relocated towards more complex manufacturing industries, setting the country's manufacturing sector on a promising trajectory of industrial upgrading. Alongside these developments, growth in exports of highly complex Information and Communication Technology (ICT) services seems to have been supported by a relevant share of employment in the formal sector, but not the informal sector, which concentrated

largely in subsistence agricultural activities and has become less complex over time. We conclude that the creation of capabilities in the household sector will be crucial to support the complexification of Ghana's productive structure.

The remainder of the paper is structured as follows. Section 2 reviews the structural change literature, focusing in particular on empirical works on structural change in Africa, and highlighting the relevance of the present contribution to the existing literature. Section 3 outlines the empirical strategy and the methodology used for the analysis. The results of the analysis are presented and discussed in Section 4. Section 5 concludes.

2 Literature review

2.1 Structural change and complexity

In early works, structural change is described as the transition of activities from traditional low-productivity sectors to modern productive sectors, with the traditional sectors supplying 'unlimited labour' to the modern sectors, and favouring higher productivity gains (Lewis, 1954). Chenery's (1979) pioneering empirical research confirmed that structural transformations were characterised by a decrease in the share of labour employed in subsistence agriculture and a shift of labour to novel and more productive sectors.

Observation of the industrialisation process in contemporary developed countries reveals the pivotal role of productivity gains for consolidating urban labour markets and spurring diversification (Kuznets, 1966). In particular, the role of diversification emphasises the importance of the emergence of new industries through the creation of backward and forward linkages (Hirschman, 1958): new economic activities (especially manufacturing) represent a new source of intermediate and final demand, which allows the creation of new productive activities in upstream and downstream industries. From a the structuralist perspective, industrialisation and manufacturing, via capital accumulation, are considered crucial for transforming economies, absorbing unproductive labour (Lewis, 1954; Rostow, 1959) and acting as an 'engine of growth' due to the presence in the modern, capital intensive sector characterised by increasing returns. Kaldor's first two empirical laws (1966) formally test the "engine of growth" hypothesis, showing that output growth in manufacturing has a positive and more than proportional effect on economic growth and productivity in manufacturing industries. Such positive feedback was earlier defined by Myrdal (Myrdal, 1957) as "cumulative causation."

The evidence in Rodrik (2013, 2018) provides further support for the importance of manufacturing activities for sustaining economic growth and shows that manufacturing productivity converges unconditionally across countries, meaning that productivity in manufacturing depends less on the so-called "growth fundamentals" (such as institutional

quality and human capital) and more on the intrinsic dynamics of manufacturing productivity which lead to increasing returns and make it a powerful engine of growth – especially in low- and middle-income countries.

More recently, and from a different disciplinary perspective than the structuralist tradition, Hidalgo, Klinger, Barabasi, and Hausmann (2007) provided a more granular view of the part played by different products in the process of economic development. The authors developed an analytical tool – the "product space" – which allowed them to identify which baskets of exported products are most conducive to economic development. They show that the most difficult to produce products are those that require high levels of knowledge and, therefore, are a rare component of the product basket. Also, the countries with Revealed Comparative Advantage (RCA) in these products are those that are more developed. Therefore, this framework, which is a-theoretical and completely data driven, assumes a correlation between a high level of knowledge intensity in the country, a high level of production capabilities and a high level of product sophistication. The more sophisticated the product, the more it is an indication of the complexity of the capabilities required to produce it. The authors use this information to measure the stock of 'capabilities' embedded in the particular country's export basket, that is, the Product Complexity Index (PCI) (Hidalgo & Hausmann, 2009).

Their analysis uses trade data and starts from the assumption that national capability to export a specific product depends on national capacity to export the related product, since these activities require similar institutions, infrastructure, physical factors and technology. Countries tend to accumulate the capabilities to produce and export products that are 'similar' to those that they already export. By moving from less sophisticated products, which require lower capabilities, to more sophisticated products, which require higher capabilities, a country can transform its economic structure in such a way that it sustains growth. In this framework, the capabilities embedded in the country's productive structure are seen as a precondition for economic development and diversification, which involve the mobilisation of knowledge and productive capabilities across sectors (Hausmann et al., 2014). This conceptualisation of economic complexity paved the way to the development of several measures of economic complexity of products, industries and geographical areas[3]

However, countries do not always and not easily move towards more complex products. There are several factors that can push countries to specialise in low productivity sectors; these include their natural resource endowments, an overvalued currency, a rigid labour market (McMillan et al., 2014) and the industrial specialisation and competitiveness of other countries (Baldwin, 2013). Achieving specialisation in complex products will be harder for countries specialised in the production of low-complexity goods that are not 'related' to higher complexity products – such as natural resources. Basically, the concepts of complexity and relatedness are closely coupled to the concept of high development

linkages in the Hirschman framework referred to above. This means that (products) sectors, such as natural resources, that are unrelated (poorly linked) to other more productive sectors (complex products) might be detrimental to the upgrading of industry specialisation.

2.2 Structural change in sub-Saharan Africa

Despite the high GDP growth experienced since the 2000s, many African countries have failed to see a substantial shift in employment from agriculture to manufacturing. Instead, their positive economic performance has been driven, most often, by a boom in commodity prices, although this has not created new jobs (Valensisi & Davis, 2011) and has driven investment away from non-resource intensive industries and hampered diversification (Harding & Venables, 2016). This is a phenomenon that has been described as the natural resources curse (Sachs & Warner, 2001).

Structural change in African countries tends to be characterised by peculiar trajectories. Most African countries have somehow skipped the industrialisation phase. Although a large share of employment and value added is concentrated in agriculture, most of the labour leaving agriculture has transitioned towards services (Bah, 2011; McMillan et al., 2017; Szirmai, 2012). Moreover, the relative shares of employment and value added in manufacturing have reached a peak at low levels of GDP per-capita, compared to current high-income countries (Rodrik, 2016).

According to Rodrik (2016), one of the factors that has led to this "pre-mature de-industrialisation" is the change in the relative prices of manufacturing compared to non-manufacturing goods, due to the shift of global manufacturing to low wage countries in South and East Asia (Haraguchi, Cheng, & Smeets, 2017). This scenario is consistent with the model developed by Kaldor (1970), which shows that countries producing goods subject to decreasing returns (such as agricultural goods) that trade with countries with comparative advantage in the production of goods subject to increasing returns (such as manufactured goods), are likely to increase specialisation in the former types of good. In addition, labour costs in Africa have remained high (Newman et al., 2016) compared to those in other emerging economies (Benjamin & Mbaye, 2020), which has had a negative impact on competitiveness.

As a result, high shares of labour in SSA countries have moved towards less-than-average-productivity services (McMillan et al., 2014) with negative or below-average productivity growth rates (de Vries et al., 2015; Diao, McMillan, & Rodrik, 2019), ultimately increasing the size of the informal sector. However, there are some indications of an expansion in both size and productivity growth of Africa's manufacturing sector after the 2010s (Kruse, Mensah, Sen, & de Vries, 2021; McMillan & Zeufack, 2022).

It has been argued that industrialisation is a necessary step in structural change also in currently low- and middle-income countries (Haraguchi et al., 2017). Nevertheless, the role of services in low- and middle-income countries' economic growth has increased (Baccini, Fiorini, Hoekman, & Sanfilippo, 2021; Owusu, Szirmai, & Foster-McGregor, 2021; Szirmai, 2012) and, in some cases, has contributed to increasing the aggregate productivity of the economy, especially if related to manufacturing (Di Meglio, Gallego, Maroto, & Savona, 2018). However, the experience of service-led development in African countries such as Rwanda, for instance, reveals that despite the high productivity of the service sector (10 times more than agriculture in Rwanda) and the movement of labour from agriculture to high productivity industries (Ggombe & Newfarmer, 2017), the lack of technological linkages with existing domestic industries and the lack of integration of foreign actors has led to disappointing results in terms of development (Liao, Kim, Miyano, & Zhu, 2020).

2.3 Towards an analytical framework for the analysis of structural change

The previous two sections summarise two contrasting, but complementary views of how African economies have evolved. On the one hand, the structuralist literature examines changes in employment to describe the process of structural transformation in SSA, focusing on productivity as the main engine of economic transformation. In this view, the shift of labour towards the most productive activities is paramount to a country's developmental outcomes. In the case of SSA, where this has not happened, it is harder to sustain economic growth in the long run. On the other hand, the complexity literature highlights the role of capabilities, proxied by export specialisation, for determining the possible ways to transform the national economic structure. In a complexity framework, the knowledge embedded in a country's productive structure determines the path of further diversification towards related, more complex industries and, ultimately, its process of structural change.

The present study builds on and attempts to bridge between these two frameworks, putting the employment dimension of structural change at the centre of the analysis. Following the structuralist tradition, this paper looks at changes in the relative importance of finely disaggregated industries in order to identify and explain the trajectory of structural change in Ghana. This approach is complemented by insights from the complexity literature, which point to the role of capabilities in creating the conditions for virtuous structural change – exemplified by an upgrading of the productive structure.

Based on the frameworks outlined above, this paper offers multiple conceptual and methodological advancements. First, the traditional structuralist tradition is complemented with the more recent findings from complexity literature, building upon the similarities

and differences that can be combined to achieve a more comprehensive assessment of the pathways of structural change in Ghana. The differences relate to the consideration of the production structure by the structuralists, and the export specialisation by the complexity economics literature. These two are necessarily interrelated yet taken into account separately in these two approaches, while here they are reconciled in a unified production/export view. Second, the pathways of structural change are identified and explained by emphasising the role of employment. Again, this is done acknowledging that capabilities are importantly embedded in employment and are in turn characterized by sectoral specificities. Third, the empirical analysis includes the role of the informal sector, which predominates in Ghana and other SSA countries. The structuralist and the complexity literature most often disregard the role of informal activities in structural change. There are some exceptions: Diao and McMillan (2018) highlight the importance of the expansion of the non-tradable sector for bringing the productivity gains required to trigger a virtuous process of structural change – what Lewis (1979) referred to as the "between sector". It has been pointed out, also, that informal firms can be the agents of bottom-up industrialisation (Kraemer-Mbula & Monaco, 2020), given their considerable innovation activities (Fu, 2020). Fourth, the empirical analysis in this paper uses an alternative measure of complexity that accounts for national capabilities, building on the country's employment – rather than export – specialisation, building on the consideration that exports alone may not be a good representation of a country's industrial composition, especially if there is a large share of labour employed in non-tradable activities. While a few studies use the employment structure to measure the complexity (Sbardella, Pugliese, & Pietronero, 2017) or the industrial specialisation of regions (Cicerone, McCann, & Venhorst, 2020), there are no empirical works that account for the informal sector in their measurement of complexity in low- and middle-income countries. Providing information on whether informal labour is shifting towards sectors requiring higher/lower capabilities could shed light on the direction in which the less productive workforce is moving and whether structural change is virtuous/vicious.

The present paper addresses these gaps in an analysis of ten years of structural change in Ghana. The aim is to identify the type of structural change that occurred in Ghana in the time period analysed, that is, towards higher capabilities or not, and the economic sectors affected. To provide a clear picture of the changes that have occurred in Ghana's economic structure, the analysis considers three economic sectors, each of which matters, but in different ways. These sectors are i) the trade sector, measured by exports, which captures the most competitive industries; ii) the formal sector, measured by domestic formal firms, given their importance in the process of economic diversification via forward and backward linkages (Andreoni, 2019; Hirschman, 1958); and iii) the informal sector, the largest employer in Ghana.

Also, to reflect the importance of the employment dimension of structural change, the relative size of industries is defined in terms of employment shares for the formal and the informal sector. Due to the unavailability of employment restricted to exporting industries, industry shares in the trade sector are measured using their relative exported value. Combining information on sector changes in relative employment shares, with information on industry complexity, provides an understanding of whether the patterns of Ghana's structural transformation have benefited its workforce in terms of the capabilities available in the country.[4]

3 Empirical strategy

3.1 Data

The analysis exploits four main sources on the trade, formal and informal sectors of the Ghanaian economy. Measurement of the relative size and composition of exports relies on data from the 2003 and 2013 UN Comtrade Database; measurement of the formal sector relies on the 2003 Ghana National Industry Census (NIC) and the 2014 IBES (2014); and measurement of household informal activities relies on the 2005 and 2013 World Bank Ghana Living Standard Survey (GLSS). The dataset derived from aggregation and harmonisation of these data sources considers the industry as the unit of observation, following the 4-digit International Standard of Industry Classification, rev. 3.1. The fully harmonised data is available in Appendix D. The relative size of each industry is computed for each of the three sectors between 2003 and 2013/2014.[5] For the export sector, relative size is given by the share of each industry's exports over total exports; for the other two sectors (formal firms and informal household activities) relative size is measured as the share of employment in each industry over total employment.

3.1.1 Export sector: UN Comtrade

The UN Comtrade dataset includes fairly detailed information on products exported by individual countries. Products are classified according to the Harmonised System (HS). The original Comtrade data were processed following the Bustos-Yildrim method[6] (Hausmann et al., 2014). The data were filtered for years 2003 and 2013 to allow comparability with data on formal firms and household informal activities. At the 4-digit HS classification level, the dataset includes 1,248 products in 2003 and 1,246 products in 2013. The product-level data were aggregated by summing the export values of HS products belonging to the same 4-digit ISIC industry, to allow comparability with the other two sectors.[7] Products belonging to more than one industry were counted fractionally for each industry involved.

3.1.2   Formal firms: NIC 2003 and IBES 2014

The Ghana NIC 2003 and 2014 IBES data cover the domestic productive establishments. Both sets of data are firm censuses collected in the respective years by the Ghana Statistical Office. The NIC 2003 covers all formal non-household establishments – all units of production whose physical location is fixed and can be described and traced — engaged, primarily, in mining and manufacturing, for a total of 3,519 firms. IBES 2014 covers all non-household establishments, both formal and informal and from all industries, for a total of 638,743 firms. The large difference in the number of observations between the 2003 and 2014 censuses is due to the fact that services (and all sectors other than manufacturing and mining) were included only in 2014. This is a shortcoming since all considerations about the formal productive structure must necessarily be limited to the manufacturing and mining sectors. Formal firms from IBES 2014 are identified based on the Ghana Statistical Service definition (Ghana Statistical Service, 2015), that is, that they are registered at the Ghana Registrar-General Department (RGD) and maintain formal accounts. This applies to 81,262 firms (12.73%), employing 54.45 per cent of the total labour force. While some of these firms may be involved in exporting and, therefore, overlap with the export sector, the census deliberately excludes all economic establishments based within households and, so, excludes household informal activities.

3.1.3   Household informal activities: the Ghana Living Standard Survey (GLSS)

Data on the size of informal industries is extracted from the Ghana Living Standard Survey (Ghana Statistical Service, 2019), a nationally representative sample of Ghanaian households, which provides information on both farming and non-farming activities carried out by households. The data are collected at the household level and re-sampled in 2005, 2013 and 2017 (with only the first two waves used for the present study). The non-farming enterprise module of the survey provides detailed information on many aspects of household firms and, particularly, their industry (according to ISIC rev. 3.1 for 2005 and ISIC rev. 4 for 2013) and employment size. Industry-level information is obtained by aggregating data on employment in household non-farming enterprises for each industry, along with information on agricultural plots and employed labour.

3.1.4   Additional data

The analysis also uses some additional data to describe long-term structural change in Ghana. The World Bank World Development Indicators (WDI) (World Bank, 2022) provide information on Ghana's GDP between 1960 and 2010. These data are complemented by the Groningen Growth and Development Centre African Sector Database (Timmer, de Vries, & De Vries, 2015), from which information on aggregate employment and value

added relative shares (agriculture, mining, manufacturing and services) over the same time period is extracted. Finally, to validate the complexity and fitness framework, the analysis in Appendix C uses VIIRS time series data (Elvidge, Baugh, Zhizhin, Hsu, & Ghosh, 2017) on Nighttime Light imagery to measure economic development at the subnational level.

3.2   Methodology

As explained in Section 3.1, our data includes information on industry shares for the trade, formal and informal sectors over a period of around 10 years (2003-2013/14). The direction of the industrial transformations in the three sectors considered relies on a measure of the sophistication of each industry in each of the three sectors: that is, the Industrial Complexity Index (ICI). The ICI is a synthetic measure of the level of productive capabilities likely to be required for a country/region to specialise in a given industry (Hidalgo & Hausmann, 2009; Tacchella et al., 2012). That is, to become competitive in a more complex industry, the country/region would need first to become competitive in a less complex industry. An increase in the complexity of the industry mix in which the country/region specialises, suggests a pattern of virtuous structural change.

Since the analysis conducted here focuses on a single country, the computation of the ICI relies upon districts (Admin-2 geographical units in Ghana) and industries to construct a bipartite network between the two dimensions. In the formulation proposed by Tacchella et al. (2012), two elements contribute to industrial complexity. First, non-ubiquity of industries, that is, only a few countries/regions are specialised in the particular industry. Thus, non-ubiquitousness is used to proxy for the uniqueness of the capabilities required to specialise in a given industry. The second element is the degree of regional (or national) diversification, where diversification signals presence of a wide range of capabilities. Therefore, the "fitness" of an entire country/region, or the complexity of an industry, can be measured by combining information on its diversification and the complexity of the industries in which it is specialised.

There are several existing measures of industry and country complexity and fitness such as the Product Complexity Index[8] based on Hidalgo and Hausmann (2009) or the fitness[9], based on Tacchella et al. (2012). However, in the context of the present analysis, these measures present a number of shortcomings, namely that they are only based on export specialisation. For this reason, the measure of industrial complexity used here – the Industry Complexity Index – builds on employment-based regional specialisation, employing the fitness algorithm proposed by Tacchella et al. (2012). The reason for this is that the Fitness algorithm better takes into account the non-linearities in the relationship between diversification and ubiquitousness (Freire, 2021; Pietronero et al., 2017). Differently from Tacchella et al. (2012) we use an employment- rather than export-based specialisation matrix, following an approach similar to Sbardella et al. (2017), and adopt Ghanaian

districts as geographical unit of analysis (other examples of works computing fitness for subnational units are Barbieri et al. 2022; Pugliese and Tacchella 2020; Pugliese and Tübke 2019; Sbardella, Zaccaria, Pietronero, and Scaramozzino 2021), and industries for production. A static ICI is computed using the rich data provided by the IBES for all 4-digit ISIC industries (249) in 2014. The computation uses information related to all 638,743 (formal and informal) Ghanaian productive establishments. The analysis uses the ICI built for 2014, over the overall industry space, to measure changes in the complexity of exports, formal firms and informal household activities, between 2003 and 2014.

The ICI is computed as follows. Employment in productive establishments aggregated by district (216 in total) is cross-tabulated with industry-level employment. The cross-tabulation is used to construct a district-industry specialisation matrix, capturing district specialisation across industries. Following the method proposed by Balassa Balassa (1965), district d is specialised in industry i if its employment share in that industry is higher than the national average employment share in the same industry. The district-industry specialisation matrix M_{di} is defined as follows; the matrix cells take value 1 if the district is specialised in an industry, and 0 otherwise:

$$
M_{di} = \begin{cases} 1 & \text{if} \quad \frac{x_{d,i}}{\sum_i x_{d,i}} \times \frac{\sum_{d,i} x_{d,i}}{\sum_d x_{d,i}} \geq 1 \\ 0 & \text{otherwise} \end{cases}
\tag{1}
$$

where $x_{d,i}$ is employment in district d and industry i. The M_{di} matrix provides information on district diversification (i.e., the number of industries in which a district is specialised, given by the row sums of the specialisation matrix) and on the industry ubiquity (i.e. the number of districts that specialise in a given industry, given by the column sums).

This information is used to compute, iteratively, a measure of district fitness (F_d), which depends on the complexity of the industries in which that district is specialised (Q_i), i.e. the ICI[10] which in turn depends on the district fitness, F_d. The district fitness correlates positively with district's diversification, weighted by the complexity of the industries in which the district is specialised. Industry complexity Q_i is inversely proportional to the ubiquity of the industries in which districts are specialised, but is positively correlated with their fitness. These relationships are formally expressed in the following algorithm:

$$
\begin{cases} \tilde{F}_d^{(n)} = \sum_i M_{di} Q_d^{(n-1)} \\ \\ \tilde{Q}_i^{(n)} = \dfrac{1}{\sum_d M_{di} \dfrac{1}{F_d^{(n-1)}}} \end{cases} \quad \text{with} \quad F_d^{(0)} = 1 \;\; \forall d \;\; \text{and} \;\; Q_i^{(0)} = 1 \;\; \forall i
\tag{2}
$$

After the first iteration ($n = 1$), the fitness F of district d corresponds simply to its diversification, while the complexity Q of industry i is equal to the inverse of its ubiquity. At each iteration the two measures are weighted progressively, using the complexity of the industries in which district d is specialised to refine district fitness, and the fitness of the districts specialised in industry i to weight complexity. In our data, both measures reach stability after 20 iterations of the algorithm.[11]. It was not possible to compute the ICI for all the industries present in the export sector. According to the trade data, Ghana exports products in industries that do not include any domestic firms. This issue will be discussed later in the results Section 4.[12]

To assess the validity of the employment-based measure of industry complexity (ICI) empirically, Appendix C reports the results of an analysis of the correlation between district fitness and economic development, measured using average nighttime luminosity (Elvidge, Baugh, Anderson, Sutton, & Ghosh, 2012). The results show a strong correlation between district average ICI and district economic development. This is in line with a growing stream of work showing that economic complexity is a good predictor of economic development (Castañeda, Pietronero, Romero-Padilla, & Zaccaria, 2022; Cristelli, Tacchella, Cader, Roster, & Pietronero, 2017; Tacchella, Mazzilli, & Pietronero, 2018).

To summarise, the final industry-level dataset, which includes the start and end years for the three sectors, contains: i) the relative share (exported value or employment) of each industry; and ii) the ICI of each industry. The former is used to study and compare structural change in the three sectors: that is, the percentage change in the share of each industry between 2003-2013. The latter is used to study and compare the direction of structural change in each sector: that is, whether the variation in industry shares has led to higher complexity of the industrial composition. We propose a weighted measure of change in relative size within the major ISIC groups j[13]:

$$\Delta X_{jk}^{ICI} = \sum_{i \in J} \left(\left(X_{ijk_{t+1}} - X_{ijk_t} \right) \times ICI_{ij}^{std} \right) \tag{3}$$

where ΔX_{jk}^{ICI} is the complexity-weighted size change in the major group j in the sector k; $(X_{ijk_{t+1}} - X_{ijk_t})$ is the variation in the share of industry i in the major ISIC group j and sector k over the time period considered; and ICI_{ij}^{std} is the ICI of industry i, logged and standardised between 0 and 1. The complexity-weighted change in the industry share indicates whether the relative changes within each sector k and each industry group j contribute positively ($\Delta X_{jk}^{ICI} > 0$) or negatively ($\Delta X_{jk}^{ICI} < 0$) to the aggregate complexity of each sector.

4 Analysis and results

This section begins with an overview of aggregate historical trends in structural change in Ghana. Then, it describes how its productive structure changed in the trade sector (2003-2013), in the formal sector (2003-2014) and in the household sector (2005-2013). These changes are qualified in terms of shifts in the complexity of the industrial composition of each sector. As argued in Section 3.2, the employment-based ICI captures the intensity and diversity of the capabilities required to specialise in a given industry. Change towards a relatively larger share of more complex industries (in each of the three sectors) are interpreted as an upgrading of the productive structure – that is, a virtuous structural change.

4.1 Structural change in Ghana

Since the 1980s, Ghana has recorded a steady annual growth rate of around 5 per cent of the GDP, peaking at 14 per cent in 2011 and then slowing to reach 0 growth at the beginning of 2020 as a result of the Covid-19 pandemic (World Bank, 2022). Exports also increased more or less steadily up to the early 2000s and accounted for 35 per cent of the total GDP in 2017 (African Development Bank, 2019). The evolution of the manufacturing employment and value-added shares is consistent with the pre-mature de-industrialisation narrative (Rodrik, 2016): when compared with a sample of seven developed countries (Japan, South Korea, Italy, Spain, France, UK and US), the share of manufacturing value added and employment in Ghana peaked at lower levels of GDP per capita and never reached the levels achieved by these other countries (Figure 1). Figure 2 shows that the decline in the shares of employment and value added in agriculture was accompanied by an increase in services and, more recently, an increase in mining since 2008, following the discovery of oil in Ghana. In terms of employment, manufacturing shares have remained at low levels since 1960 and in terms of value added, have even decreased.

The aggregate figures presented above provide a general description of the composition of employment and value-added in formal activities but may not apply to all sectors of Ghana's economy. The reason why formal production cannot be used, on its own, to measure Ghana's economic structure, is that the weight of the informal sector is high. The most recent data from the Ghana Statistical Service suggest that the informal sector accounts for 28.6 per cent of GDP (Ghana Statistical Service, 2015), which is comparable to the weight of exports (35% according to the World Bank 2022). In terms of employment, the informal sector accounts for 46.45 per cent of the active workforce employed in non-household establishments (Ghana Statistical Service, 2015).[14].

The existence of a large informal sector highlights the limitations of Figures 1 and 2 in outlining the process of structural change in Ghana. Also, the contribution of non-
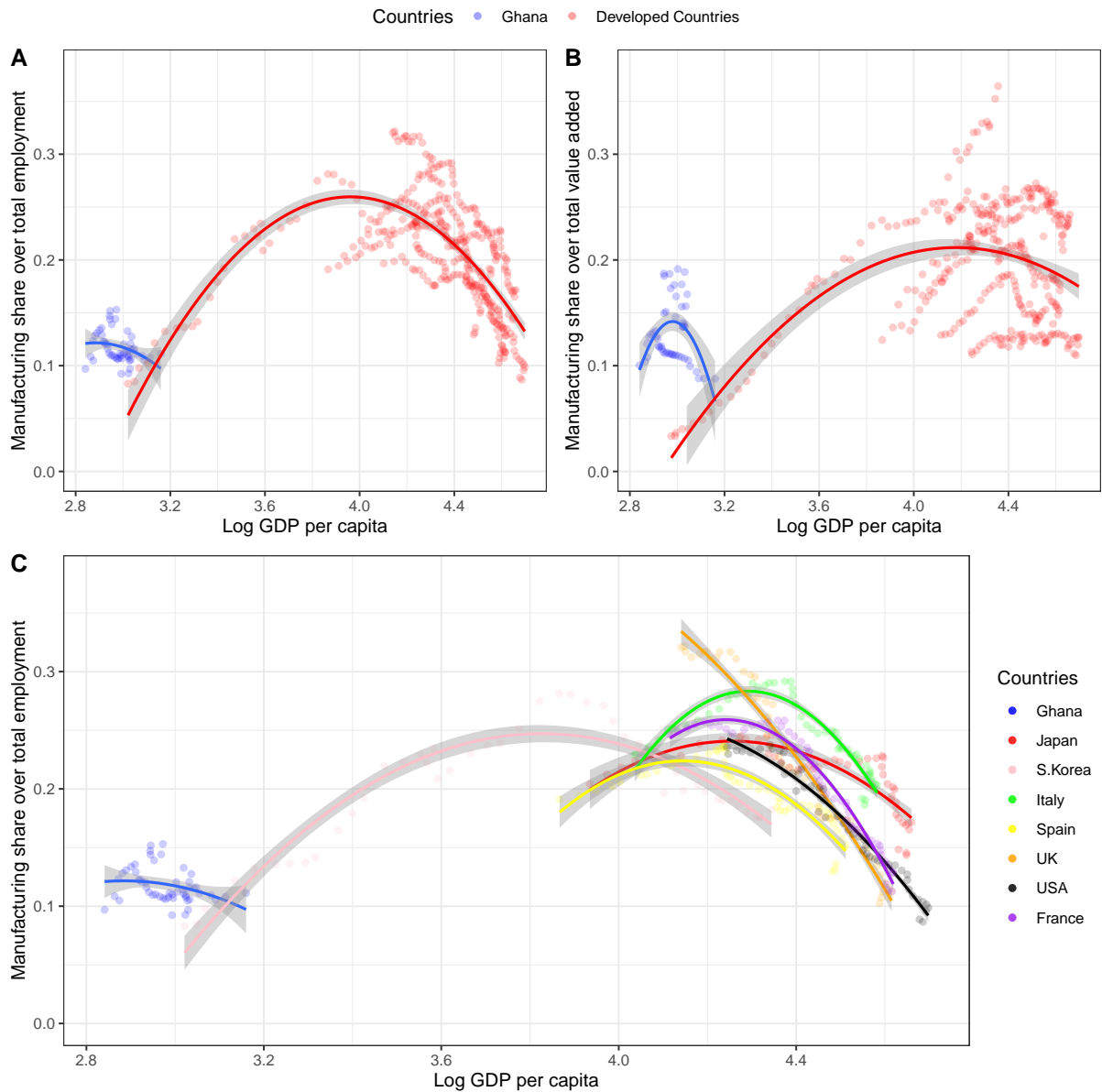
Figure 1: This figure plots GDP against the share of manufacturing in total employment (panel A) and total value added (panel B), comparing Ghana with a sample of 7 high-income countries (Japan, Korea, Italy, Spain, France, UK and US). The figure is based on data on GDP per capita, and manufacturing employment and value added between 1960 and 2013. Panels A and B compare Ghana with the average high-income country in the sample; panel C compares Ghana with the 7 countries individually. Fitted lines represent the quadratic fit between the two variables on the X and Y axes. Sources: African Sector Database, Groningen Growth and Development Centre (manufacturing employment and value added); WDI (GDP per capita)
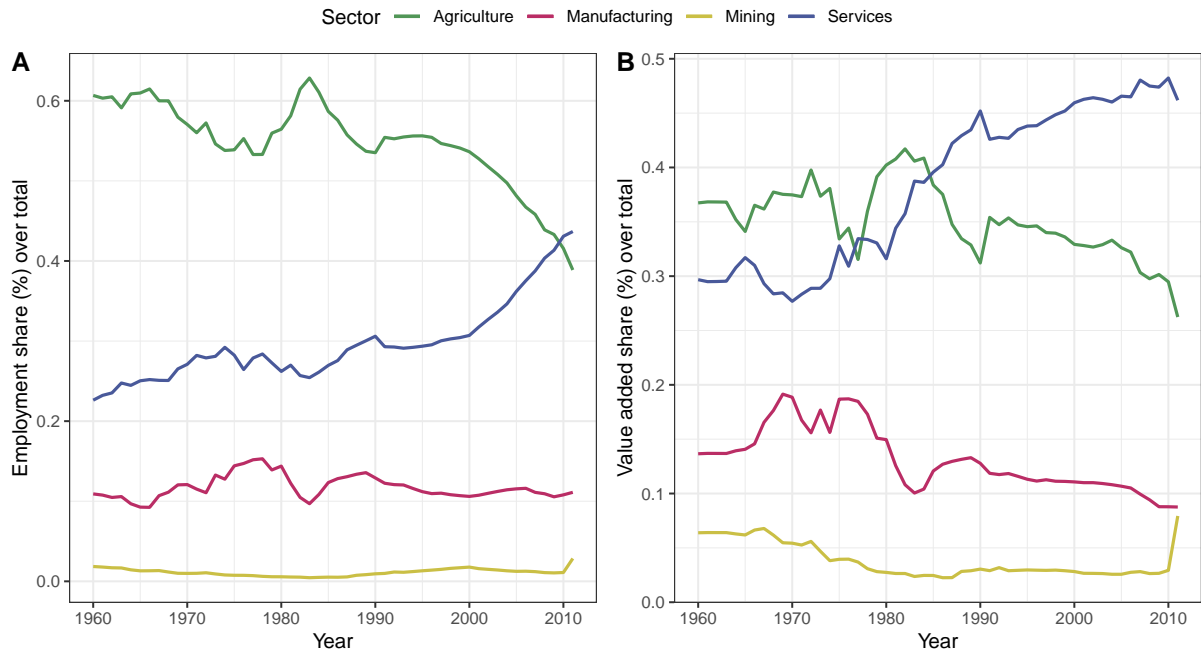
Figure 2: Employment and value added trends in agriculture, manufacturing, mining and services (Ghana, 1960-2011). Source: WDI

farming household enterprises has increased over time in low- and middle-income countries (Haggblade, Hazell, & Reardon, 2010; Nagler & Naudé, 2017), although they have been moving to services rather than manufacturing (Jayne, Chamberlin, & Benfica, 2018) and their creation is often motivated by geographical factors, such as proximity to urban centres (Christiaensen, Weerdt, & Todo, 2013; Djido & Shiferaw, 2018).

To fully account for the Ghanaian productive structure, the following subsections compare three distinct, but interrelated economic sectors: i) the trade sector, measured by export activities, which correspond to more internationally competitive activities and, therefore, industries holding a comparative advantage; ii) formal domestic activities, defined here as all activities carried out in formal establishments; and iii) household enterprises, that is, activities carried out by households – mainly informal, both on- and off-farm. The next section describes the results for each of the three sectors.

4.2 Export sector

Figure 3 compares the share of export value in 2003 (X-axis) with the share of export value for the same industry in 2013 (Y-axis), showing that while most activities account for less than 5 per cent of the exports in both years, Ghana's export composition has changed substantially towards the extractive industries. We observe that the share of exports of unrefined petroleum and natural gas jumped from 0 per cent in 2003 to 20 per cent of total exports in 2013, as well as a noticeable growth of 7 pp in the share of manufactured basic precious metals (from 18% to more than 25%). Among the larger

export sectors, ICT shares increased from 3 per cent to 5 per cent, while the share of fruit, nuts, beverage and spice crops in total exports decreased from 27 per cent to 13 per cent; travel and tourism decreased from 14 per cent to 5 per cent. These figures seem to confirm a picture of an economy whose reliance on agriculture is decreasing, although it is shifting to another primary industry that relies on export of extractive natural resources.

Figures 3A and 3B show that some of the growing manufacturing activities seem to be related to the processing of natural commodities, hinting at an opportunity for functional upgrading in their respective value chains. One such example is the gold value chain, given the increase in the export of manufactured basic precious metals (Figure 3A). Another is the cocoa value chain, which experienced a decrease in the export of the raw commodity (Growing of fruits, nuts, beverage and spice crops sector 3A), coupled with an increase in manufactured products (Manufacture of cocoa, chocolate and sugar confectionery 3B). However, the manufacture of refined petroleum products shrank by almost a half over the same period, indicating that export-oriented firms in Ghana have specialised in the extraction rather than the processing of oil.

Overall, the relative share of traditional manufacturing activities in exports has been declining. While in Africa as a whole, current trends show that the decrease in the relative share of agriculture has been coupled with the increased relevance of services, this does not apply to the Ghanaian export sector. Although the relative weight of ICT increased between 2003 and 2013, this has been more than offset by the reduced shares of other tradable services (travel and tourism). Overall, the share of the service sector in exports has decreased in Ghana.

To investigate whether these changes in the export structure implies a virtuous or a vicious structural transformation, the change in the traded industries' relative shares is combined with ICI. Figure 4 shows that the highest increase among industries for which was not possible to compute an ICI is observed for the manufacture of basic precious and non ferrous metals. The fact that Ghana exports products from this industry might indicate that: those products are imported and then re-exported by companies specialised in other industries; that production activities in this industry are carried out by multinational corporations; or that the products are made by firms whose secondary sector of activity is the manufacture of basic precious metals. In all these cases, the benefits to local firms and workers may be non-existent or reduced. First, re-export of products does not provide any information on the country's productive capabilities. Second, in the case of production conducted by multinational corporations, the benefits, in terms of capabilities and technology transfer, will depend on each firm's use of domestic skilled and unskilled workforce. Third, if the manufacture of basic precious metals, such as gold, is not the main sector of activity of the domestic formal firm, it will represent only a minor contribution to the domestic productive structure.

Figure 4 also reveals a large increase in the share of industries whose complexity is higher than the sample mean (in green), such as ICT[15] and oil and gas extraction. At the same time, the industry showing the biggest decline in exports share is the growing of fruits and nuts, beverage and spice crops, a low-complexity industry, accompanied by a small increase in the share of manufactured goods linked to these crops (manufacturing of cocoa, chocolate and sugar confectionery), which is also a low complexity industry.

Table 1 summarises the direction of structural change in the Ghanaian export sector based on the pp change in relative industry shares, aggregated by ISIC major groups (1-digit ISIC, second column), the (logged and standardised) average ICI of the 1-digit industry (third column), and the sum of the products of all the changes in relative share of 4-digit ISIC industries by their complexity, by industrial group (fourth column). This last measure captures the change in relative share of each ISIC major group, weighted by the complexity of the 4-digit ISIC industries, as described by Equation 3. The table shows that there was an increase in exported manufactured products that was much lower than in mining, but higher than in services. However, this might be because exports do not include non-tradable services. Moreover, the three macro industries which show the highest level of growth (manufacturing, mining and ICT) are also among those sectors with the highest average complexity; the only high-complexity sector that has been decreasing between 2003 and 2013 is transport. Overall, the trade sector appears to be moving towards more complex activities (especially in mining and manufacturing), and away from the export of agricultural commodities. The overall complexity-weighted export change, obtained by summing all the available complexity weighted changes at the 4-digit industry level, is positive (+2.49), indicating an aggregate shift of production towards more knowledge-intensive activities.
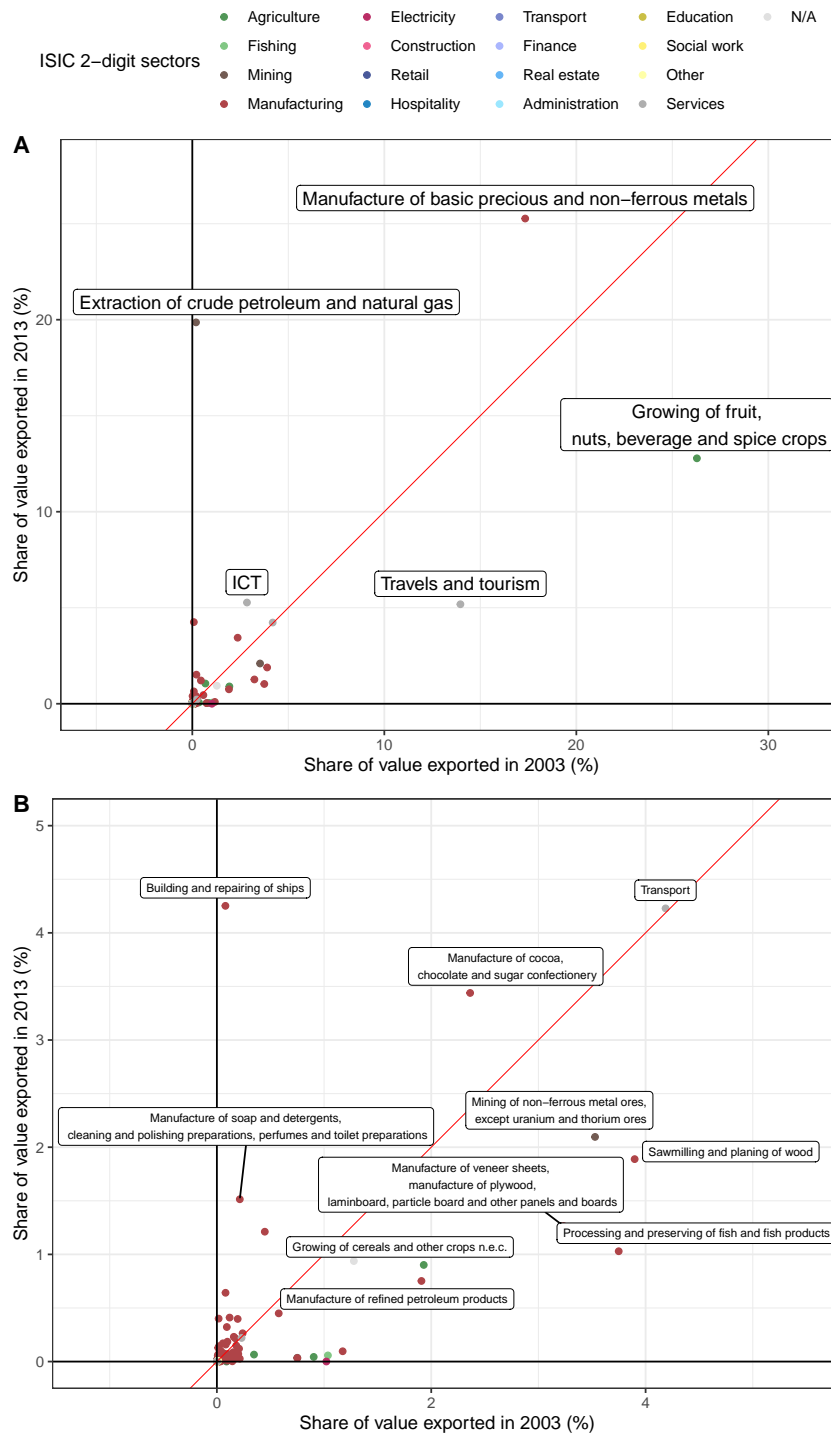
Figure 3: The dots in the scatterplot represent a different 4-digit ISIC industry in the trade sector; the different colours indicate the major ISIC group. Industries with a constant relative weight over time lie on the 45° line; industries closer to the X axis and far from the Y axis have experienced a decrease in their relative weight between 2003 and 2013. Industries that are closer to the Y axis (2013) and far from the X (2003) axis are those that have experienced a change in relative weight over time. Panel A includes all 4-digit industries; panel B zooms in on those industries with a share lower than 5% in both years.
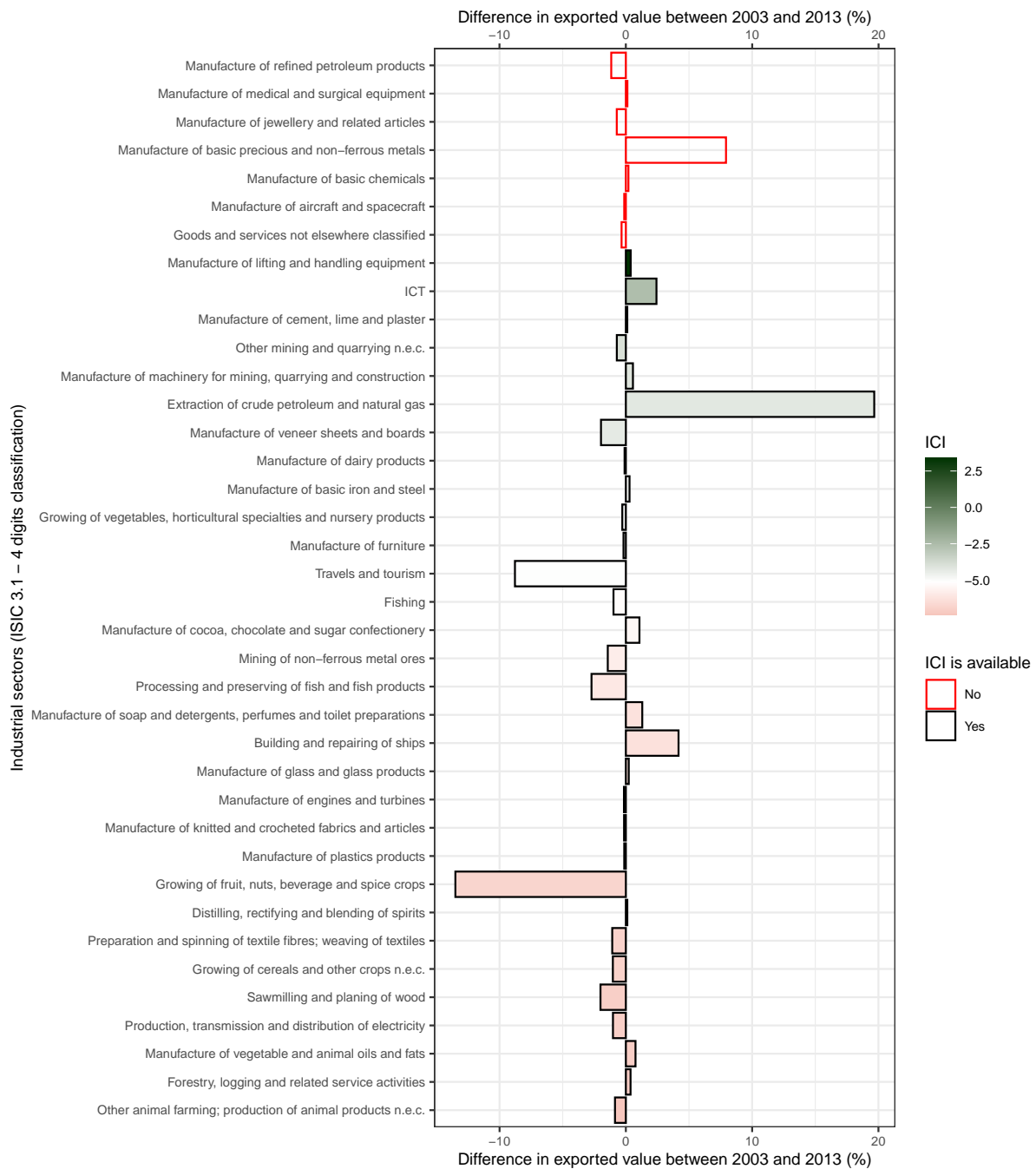
Figure 4: The length of the bins represents the difference (in pp) in the relative shares of each export industry between 2003 and 2013. Positive values indicate an increase in exports in 2013 and negative values indicate a decrease in exports in 2013. The colours indicate the complexity of each industry, from low (red) to high (green); values around the mean are in white. Empty red bars indicate industries where the ICI is not available. Industries varying by less than 0.1 pp are excluded from the diagram.

Table 1: Changes in export shares by ISIC major groups

ISIC group	Export difference	Avg. complexity	Weighted export change
Administration	0.000	0.144	0.000
Agriculture	-15.385	0.162	-2.251
Construction	0.000	0.220	0.000
Education	0.000	0.086	0.000
Electricity	-1.021	0.177	-0.132
Finance	-0.010	0.252	-0.003
Fishing	-0.978	0.262	-0.256
Hospitality	0.000	0.116	0.000
ICT	2.424	0.461	1.116
Manufacturing	6.604	0.325	0.385
Mining	17.453	0.445	6.062
Other	-0.007	0.170	-0.001
Real estate	0.000	0.304	0.000
Retail	0.000	0.187	0.000
Social work	0.000	0.127	0.000
Transport	-8.741	0.358	-2.425

Note: Total relative export difference measured as pp change between 2003 and 2013, average complexity of the 4-digit industries in each group, and 4-digit level change in exports, weighted by the ICI (also 4-digit ISIC) and summed by ISIC group are indicated for each 1-digit ISIC group.

4.3 Formal firms

The analysis of the formal sector is restricted to the manufacturing and mining industries, since the 2003 National Industry Census focused only on these two. This means that industry shares here refer only to the employment percentages in these two groups and not all industries. However, Figure 13 in Appendix A depicts the full composition of domestic formal employment in 2014, for all industries, and shows the wide range of economic activities beyond the manufacturing and mining industries. Visual inspection of Figures 5A and 5B reveals an increase in mining activities, such as mining of non ferrous metal ores, mining and agglomeration of hard coal and extraction of crude petroleum and natural gas. In the case of oil extraction, while its relative share in formal employment grew between 2003 and 2013, its relative employment size is smaller compared to the share of export value. This suggests that, despite the large revenues generated by oil exports, extraction of this natural resource has only a comparatively modest capacity to absorb labour and is not likely to drive structural change involving higher levels of employment.

Similar to the export sector, the formal sector experienced a decrease in the relative share of some traditional manufacturing activities, such as manufacture of wearing apparel, and in activities linked to wood processing (sawmilling and planing of wood and manufacture

of furniture). However, traditional manufacturing has grown elsewhere in relative terms, including the manufacture of footwear and the manufacture of vegetable and animal oils and fats. Interestingly, the nuclear fuel processing industry has also grown – and quite considerably – between 2003 and 2013, probably as a result of the development of several nuclear projects in Ghana. However, there are some concerns about their long-run sustainability (Ramana & Agyapong, 2016).

Figure 6 shows that more complex formal industries (in green) grew, although the largest growing industry is the low complexity mining of non ferrous metal ores industry (which includes mining of gold). The industry that has shrunk the most is the manufacture of apparel, one of the least complex industries. Another industry that has declined is the manufacture of furniture, which is more complex than the mean industry in the sample. Table 2 summarises the changes in (complexity-weighted) employment by major ISIC groups (restricted to manufacturing and mining only). On the one hand, the manufacturing employment figures (second column) seem to confirm a continuing trend towards de-industrialisation, with mining activities gaining weight relative to manufacturing. On the other hand, complexity-weighted employment change (fourth column) indicates that, although employment has generally moved away from manufacturing, more complex industries have grown, making the measure positive. This suggests that although aggregate labour has decreased, there is a shift from employment in low-complexity manufacturing activities towards more complex activities. In the formal sector, the aggregate complexity-weighted employment change is +6.45. However, while these figures suggest a trajectory of growth-enhancing structural change, it should be remembered that the mining and manufacturing sector accounted for only 17 per cent of formal employment in Ghana in 2014 and that the aggregate employment figures indicate that, over the time period considered, the share of labour in services increased.

Table 2: Changes in employment shares (formal sector) by ISIC major groups

ISIC group	Emp. difference	Avg. Complexity	Weighted emp. change
Mining	18.926	0.439	4.684
Manufacturing	-7.407	0.318	1.762

Note: For each ISIC group (1-digit ISIC, only manufacturing and mining), this table indicates the total difference in employment shares measured as the pp change between 2003 and 2014, the average complexity of the 4-digit industries in each group and the 4-digit level change in employment shares, weighted by the ICI (also 4-digit ISIC) and summed by ISIC group.
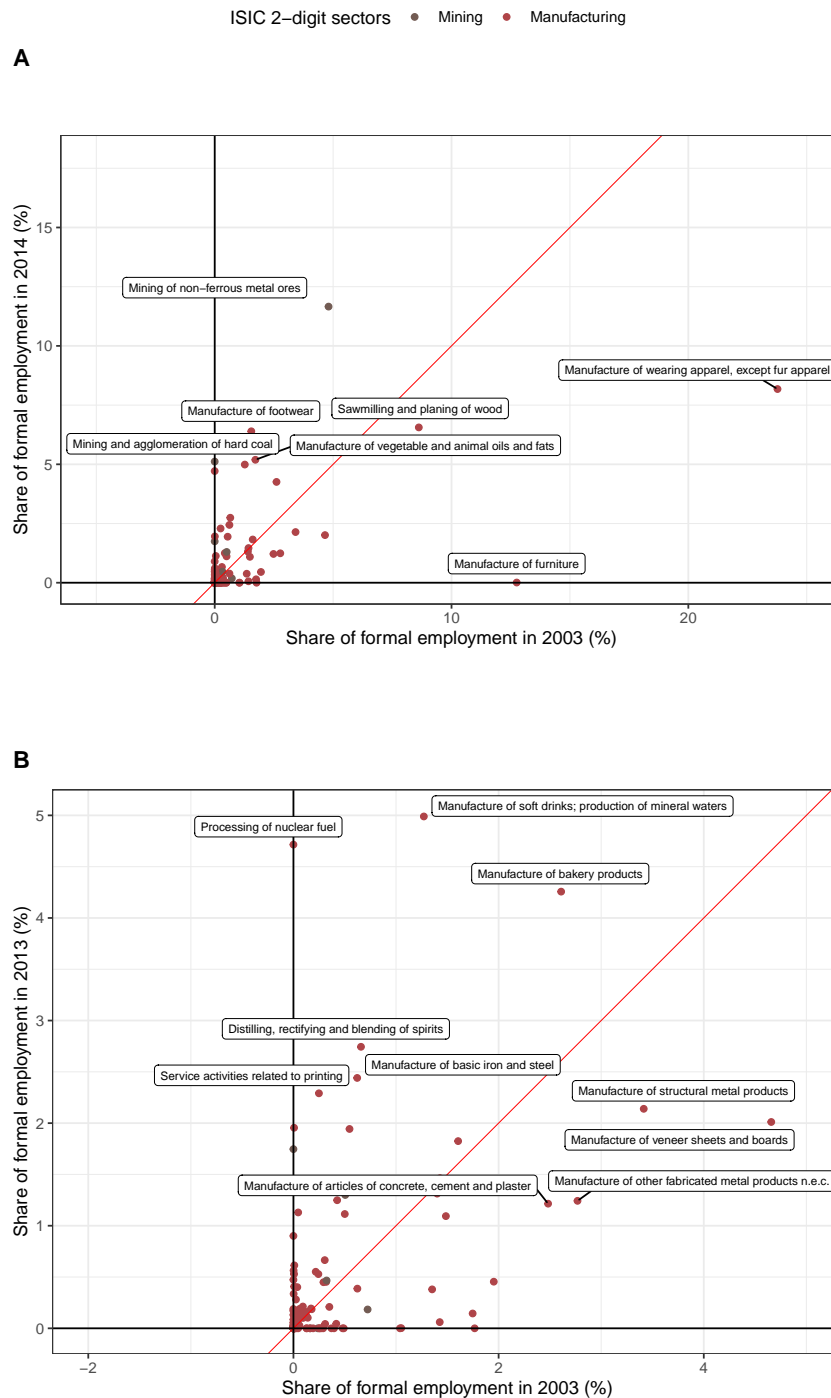
Figure 5: The dots in the scatterplot represent a 4-digit ISIC industry in the formal sector; the colours indicate the major ISIC group. Industries with a constant relative weight over time lie on the 45° line; industries closer to the X axis and far from the Y axis have experienced a decrease in relative weight between 2003 and 2014. Industries that are closer to the Y axis (2014) and far from the X (2003) axis are those that experienced a change in relative weight over time. Panel A includes all 4-digit industries; panel B zooms in on industries with a share lower than 5% in both years.
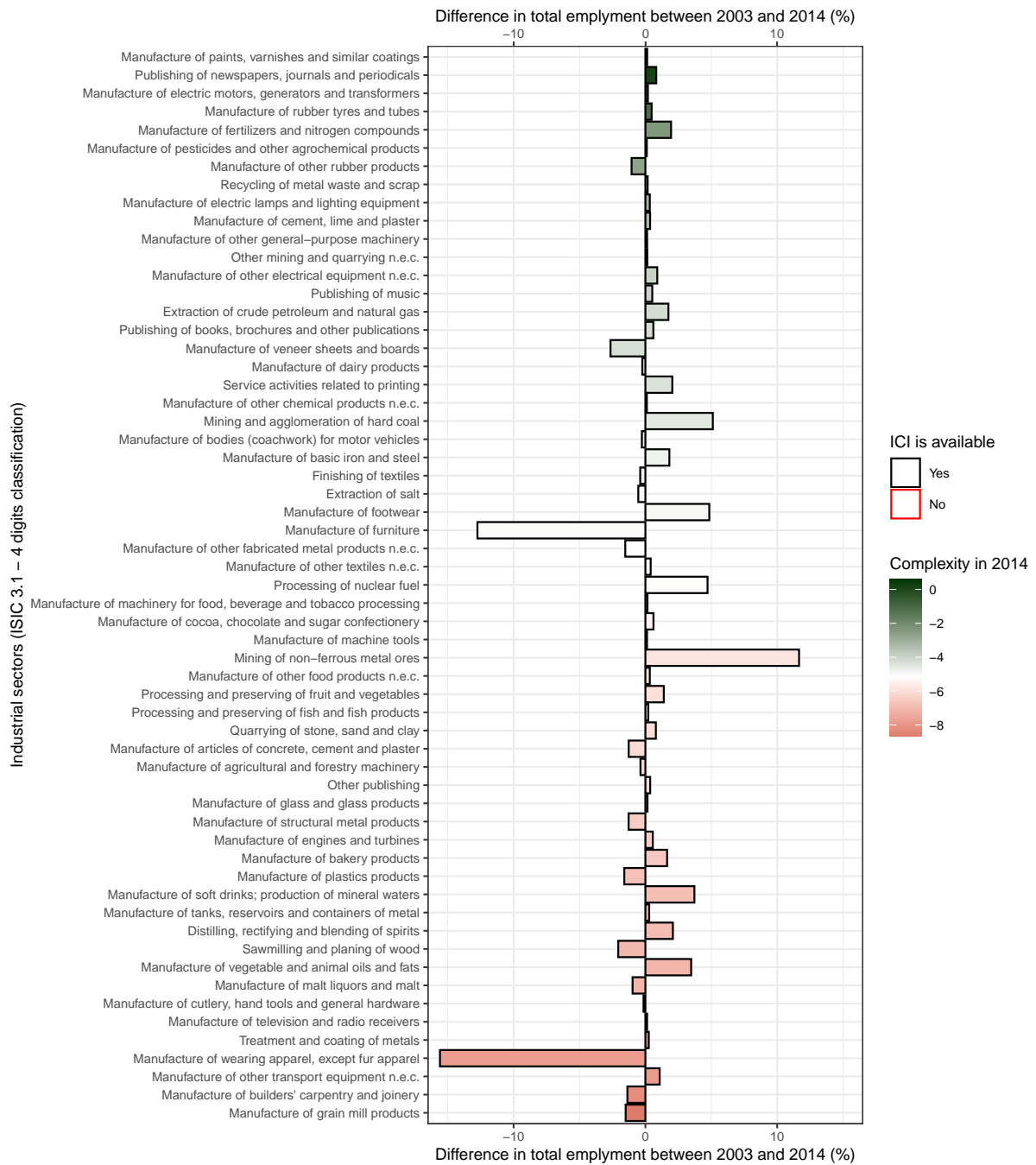
Figure 6: The length of the bins represents the difference (in pp) between the relative shares of manufacturing and mining formal industries between 2003 and 2014; positive values indicate an increase in formal employment in 2014 and negative values indicate a decrease. The colour filling of the bin indicates the complexity of each industry, from low (red) to high (green); values around the mean are in white. Empty red bars indicate industries where ICI is not available. Industries that vary by less than 0.1 are excluded.

4.4 Household informal activities

The composition of household activities shows considerable variety of activities across 4-digit ISIC industries and groups. However, this sector shows very little change over the eight year period considered (2005-2013) and is dominated by agricultural activities (see Figure 7A).[16] To improve the visualisation of employment shares in non-farming activities, Figure 7B and Figures 15 and 17 in Appendix A, exclude agriculture. From these we can observe that in both 2005 and 2013, the majority of household manufacturing activities were related to processing of agricultural products and production of food, although there was some contribution from other traditional manufacturing activities (such as the manufacture of apparel). However, these activities have decreased over time, while employment has increased in non-tradable and low-productivity activities such as wholesale and retail, repairs, hairdressing and restaurants.

Figure 8 presents the changes in complexity in the household sector. While the employment composition of household enterprises remained constant in the period of observation (2005-2013), we observe that the more complex industries are those that show the smallest changes in the relative size of employment. There is more variation across the less complex industries, with the largest change in the growing of fruit, nuts, beverage and spice crops – a low complexity industry. Similarly to the export and formal sectors, Table 3 summarises the extent to which the macro industries have changed in terms of employment, and how those changes contributed to the sector's aggregate complexity. If we compare the agricultural and manufacturing sector, we see that the former has grown in size more than the latter. However, the complexity-weighted employment change indicates that the increase in aggregate complexity of household employment in agriculture has been more than offset by the reduction of employment in manufacturing. In a few industries (hospitality and other services), employment has grown, but contributing negatively to the aggregate complexity of the informal economy. Overall, the informal sectors' complexity-weighted employment change is negative (-0.04). indicating that the small changes in relative labour shares favoured low-complexity industries.

4.5 Discussion

The mapping exercise carried out in the previous subsections provides detailed insights into the changes experienced by Ghana's industrial composition. Building on the structuralist and complexity frameworks, a set of stylised facts related to Ghana's structural transformation can be identified, regarding: i) sectoral specialisation; ii) de-industrialisation; iii) the service economy; and iv) the overall transformation trajectory.

Specialisation. The analysis of the trade and formal sectors provides evidence on Ghana's specialisation in the extraction and mining of natural resources. These activities have a
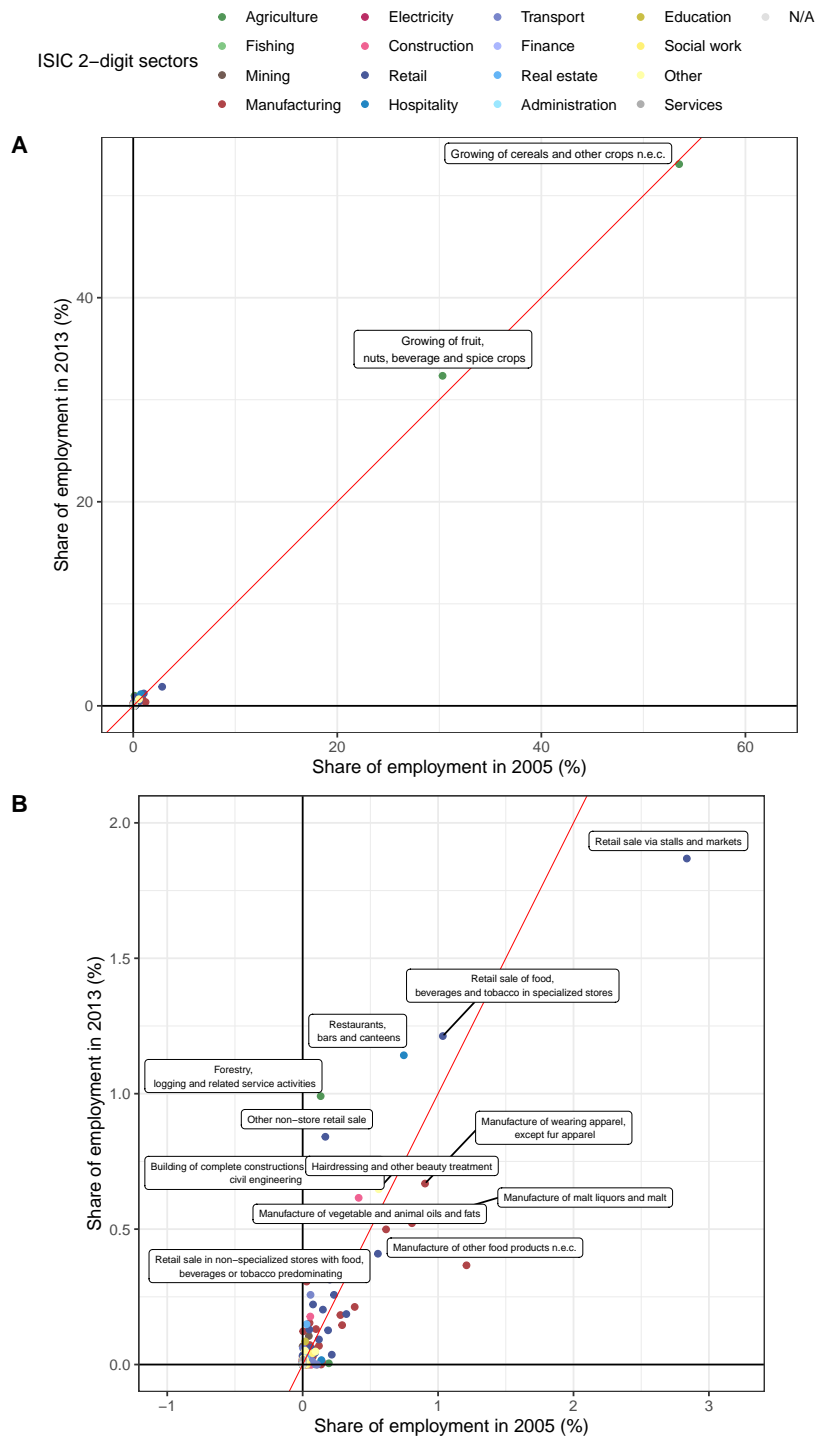
Figure 7: The dots in the scatterplot represent a different 4-digit ISIC industry in the informal sector; the colours indicate the major ISIC group classification. Industries with constant relative weight over time lie on the 45° line; industries closer to the X axis and far from the Y axis have experienced a decrease in relative weight between 2005 and 2013. Industries that are closer to the Y axis (2013) and far from the X axis (2005) are those experiencing a change in relative weight over time; panel B zoom into industries with a share lower than 2 per cent in both years.

Figure 8: The bin's length measures the difference (in percentage points) of the relative share of each informal industry between 2005 and 2013. Positive values indicate an increase in informal employment in 2013, while negative values indicate a decrease. The colour filling of the bin indicates the complexity for each industry, from low (red) to high (green); values around the mean are shown in white. Empty, red bars indicate industries for which the ICI is not available. Industries with variation lower than 0.1 are excluded for visualisation purposes.

Table 3: Changes in employment shares (household sector) by ISIC major groups

ISIC group	Emp. difference	Avg. complexity	Weighted emp. change
Agriculture	2.249	0.162	0.291
Fishing	-0.036	0.262	-0.009
Mining	0.086	0.445	0.029
Manufacturing	-2.067	0.325	-0.391
Electricity	-0.054	0.177	-0.010
Construction	0.248	0.220	0.070
Retail	-0.233	0.187	-0.028
Hospitality	0.273	0.116	-0.016
Transport	-0.006	0.364	-0.012
Finance	0.004	0.246	0.003
Real estate	0.112	0.304	0.038
Administration	0.011	0.144	0.002
Education	0.064	0.086	0.000
Social work	-0.086	0.127	-0.012
Other	0.039	0.170	-0.002

Note: For each ISIC group (ISIC 1-digit), total difference in employment shares measured in percentage points change between 2005 and 2013, average complexity of 4-digit industries in each group and 4-digit level change in employment shares, weighted by the ICI (also 4-digit ISIC), and summed by ISIC group are indicated.

high ICI, due, likely, to the fact that most are highly geographically concentrated. While the high complexity of these activities might suggest that they are facilitating related industrial diversification, employment changes in the downstream activities linked to these activities suggest that it might not be feasible for Ghana to upgrade along the respective value chains. For instance, growth in the processing of metal ores appears to be led by re-exporting, production by non-Ghanaian firms or secondary production by domestic firms (see Section 4.2). In addition, despite the high growth in exports of raw petroleum, employment in the manufacture of processed oil products shrank by almost a half, while oil extraction represents only 0.1 per cent of total formal domestic employment and 0.09 per cent of household employment in Ghana (compared to 20% of total exports). However, the increase in exports of precious metals products seems to have been accompanied by increasing employment in metal ore extraction. In terms of agricultural production, the trade sector shows a decrease in exports of agricultural products while agricultural employment in the household sector shows continuous (although slow) growth. This suggests that household agriculture is oriented more to the domestic market and that Ghanaian households have not abandoned agricultural activities, which continue to represent an important source of employment.

(De)industrialisation. We began by acknowledging the trend in Ghana towards premature de-industrialisation (Figure 1) between 1960 and 2010. The analysis provided further evidence on the composition of the manufacturing sector in Ghana, which has been observed across three different sectors. The export data seem to indicate that the relative importance of manufacturing exports is growing, although a comparison between the three sectors presents a different picture. First, the continued importance of some manufactured goods exports is not likely to benefit local employment: in fact, we have seen how the production of the fastest growing exports of manufactured goods (basic precious and non-ferrous metals) may not be carried out by Ghanaian firms. Second, in the formal sector, manufacturing has been shrinking in terms of aggregate employment (although, recall, that consideration of formal manufacturing is restricted to a comparison among the mining industries). Nevertheless, Section 4.3 showed that labour has been moving away from low-complexity to higher-complexity manufacturing industries. This pattern is consistent with recent evidence on African industrialisation, which indicates that labour productivity trends in Africa are being driven by the displacement of labour towards more productive industries (McMillan & Zeufack, 2022), in some cases, reversing the de-industrialisation trend (Kruse et al., 2021). However, the importance of manufacturing as an employer of household labour has decreased considerably, compared to other industries in the same sector. The contraction of manufacturing employment in household enterprises indicates that were the formal manufacturing sector to expand, as suggested by Kruse et al. (2021), the process of structural change could be stunted by the lack of production and entrepreneurial capabilities among informal workers and entrepreneurs.

Services. This analysis of Ghana's sectors provides some useful insights for debate on the growing importance of services in African economies (Baccini et al., 2021; Owusu et al., 2021). The composition of Ghanaian exports indicates that the relative share of tradable services has decreased overall, although the ICT sector, which is likely to be one of the sectors crucial for sustaining catch-up by low- and middle-income economies (Kaplinsky & Kraemer-Mbula, 2022), has grown. The growth in ICT exports seems to have been accompanied by some employment in ICT-related industries (1.2% in the formal sector in 2014, but zero in the household sector) and a growth in their high level of complexity, suggesting that ICT has the potential, simultaneously, to become a source of economic diversification and employment creation. Nevertheless, employment in the household sector is moving towards low-productivity services, which weights negatively on the aggregate complexity of the household productive structure.

In sum, the results of this analysis suggest a trajectory of structural change in Ghana between 2003 and 2013, characterised by growing specialisation in the extraction of natural resources, with mixed effects on employment creation. In addition, Ghana has experienced a drastic reduction in export of agricultural commodities, despite the continued

importance of agricultural activities for household livelihoods; a reduction in the size of the manufacturing sector, which has experienced some reallocation of labour towards more complex industries; and a reduction in the relative weight of tradable services (with some exceptions, such as ICT), accompanied by employment growth in low-productivity services.

There are two final implications of the structural change trajectory identified by this study. First, the analysis shows that using the industrial composition of traded industries to proxy for national productive capabilities could be misleading. We showed that some growing export industries are not reflected in domestic employment and, therefore, cannot be considered as signalling the strength of domestic economic activity or as indicators of the stock of locally available capabilities. These considerations have a methodological counterpart: in Section 3.2 we argued that using trade-based measures of complexity might be misleading since they do not account for employment composition at the country level and, also, assume that exports represent those activities in which the country is most competitive. While this latter assumption might not be misplaced, the analysis in this paper shows that, in some cases, export activities do not match domestic capabilities (in terms of industry employment) and, therefore, a measure of industrial complexity based on local, subnational employment data is more appropriate.

Second, the paper has argued that the informal sector is a crucial element in the process of structural transformation. Results from Section 4.4 indicate that while the trade and formal sectors experienced some transformation of their industrial composition between 2003 and 2013, the industrial composition of the household sector remained substantially unchanged. The results also show the informal employment structure is moving towards less complex industries, driven mainly by the continued (and growing) importance of agriculture and a contraction in manufacturing activities. This is not necessarily related to a lack of dynamism; however, the availability of capabilities in household and informal activities that match the aggregate productive structure remains crucial to foster inclusive and growth enhance structural change.

5 Conclusions

This paper contributes to the literature on structural change and industrial transformation for development, by mapping and discussing the trajectory of Ghana, one of the most successful countries in the SSA region. It adds to the synergy between the structuralist and the complexity literature, while reconciling potential differences and proposing a conceptual and empirical framework. The analysis conducted in this paper considered production alongside Ghana's export structure, using an employment-based measure of industrial complexity – the ICI – and, most importantly, accounting for the (predominant)

informal sector as well as the export and domestic formal sectors. The analysis provides a rich mapping of structural change in Ghana, which proposes novel angles and perspectives that are more nuanced than what emerges from the current scholarly literature. Most important, it offers tangible evidence which can serve as the basis for industrial policy aimed at sustainable development and structural transformation.

This study provides several results related to the trajectory of structural change in Ghana. They can be summarised as follows. First, by comparing the trade, formal and informal sectors, the analysis shows that Ghana is specialising in the extraction of natural resources, such as oil and gold, although neither activity has created employment in the downstream sectors.

Second, the analysis of structural change using employment-based complexity, complements (and in some ways contrasts with) the structuralist view that African labour has moved to less productive sectors. In fact, this paper shows that, in some cases (particularly in the formal sector), labour has moved to more complex industries, while contracting elsewhere (in the trade and informal sectors). This might have contributed to the recently documented manufacturing renaissance in Africa (Kruse et al., 2021; McMillan & Zeufack, 2022).

Third, it has been observed that, in aggregate, Ghanaian labour has moved away from agriculture towards services, skipping the industrialisation phase of structural change. However, the findings of this paper indicate that, in terms of trade composition, the relative share of services has shrunk, although the importance of more complex services has increased. On the other hand, employment in low-complexity services has grown in the informal sector.

Fourth, the relative importance of agricultural exports has decreased, although their relative importance in informal employment has grown. This challenges the view that African labour is leaving the agricultural sector and highlights yet another mismatch between levels of production in Ghana.

The above evidence offers opportunities for industry policy, with a specific focus on the informal sector. Most policy tools designed for high-income countries and adapted to low- and middle-income contexts, ignore the informal sector. The results indicate that a large room for action is due, not necessarily by favouring a shift from informal to formal, but to create synergies between the upgrading formal sector and the large, low-complexity and heterogeneous informal sector.

More specifically, bridging between the structuralist and complexity frameworks has emphasised the importance of aligning the productive capabilities of the informal sector with the Ghana's productive structure. This is crucial to allow the participation of

households in the process of structural transformation, and to ensure the availability of skills for the emerging activities, in particular those that will require an intake of workers while also facing the challenge posed by emerging breakthrough technologies such as automation-related ones, which may reduce the labour intensity of these activities.

Acknowledgments

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Notes

[1]The International Monetary Fund defines a growth acceleration as an "eight years [period] with average annual growth in GDP per capita of at least 3.5 per cent and a growth rate at least 2 percentage points higher than in the previous eight years. To rule out episodes of economic recovery, real GDP must also be higher in the last year of the acceleration period than in the years preceding it" (African Development Bank, 2019). The period between 2008 and 2016 is identified as a growth acceleration on these grounds.

[2]It has been argued that the rapid industrialisation of China since the early 2000s triggered the latest "commodity price supercycle", i.e., a steady increase in commodity prices above their long-term trends, due to large shocks that have increased demand and to which supply has been slow to respond (Erten & Ocampo, 2013; Hume & Terazono, 2021).

[3]For a broad review of complexity measures and algorithms, see Freire (2021).

[4]This approach has some limitations. First, the first year of data (2003) for the formal sector includes only information on manufacturing and mining firms, which limits examination of the changes that have occurred in the formal sector to these two industries. Second, not all industries are observed in all of the three sectors. Since the industrial complexity measure is built using the Integrated Business Establishment Census (IBES) (see Section 3.1.2), only the industries included in this dataset are used to measure the Industry Complexity Index. This limitation is discussed further in Sections 3.2 and 4.2. Third, as mentioned earlier, while the formal and informal sectors are measured in terms of employment shares, the trade sector is measured in terms of relative shares of export value. Although this does not allow to describe the trends in employment generated by exported activities, measuring the change in the composition of the trade sector is a useful reference to identify whether the changes in Ghana's export specialisation are reflected by changes in the formal and informal employment structures.

[5]The year of observation differs depending on the data source: starting in 2005 instead of 2003, for household informal activities; ending in 2014 rather than 2013 for formal firms.

[6]For a detailed description of the Bustos-Yildrim cleaning procedure applied to import-export data, see the Atlas of Complexity: http://atlas.cid.harvard.edu/data.

[7]Correspondence between HS products and ISIC industries was enabled by the `concordance` package in R (Liao et al., 2020), which allows conversion across HS, Standard International Trade Classification (SITC) and ISIC classification systems.

[8]Available at: https://oec.world/en/blog/post/2020-trends-in-economic-complexity.

[9]Available upon request: http://www.economic-fitness.com/.

[10]The complexity of industry i is referred to as Q_i, mainly in the mathematical notations, and as ICI – Industry Complexity Index – in the rest of the analysis. Fitness (F_d) refers to the complexity of geographical areas (in this case, the districts).

[11]The algorithm was implemented using the R package `economiccomplexity`, available via R's CRAN repository (Vargas, Bottai, Kozlowski, & Pintar, 2020).

[12]In the case of tradable services (such as ICT, finance, transport, and travels and tourism) the Harmonised System classification does not have a direct correspondence in terms of ISIC 4-digit industries. Therefore, it has been operated a correspondence between HS services and ISIC 4-digit industries, the

rationale of which is shown in Table 4 in Appendix B. The sectoral re-aggregation follows the special grouping guidance provided by the International Standard Industrial Classification of the United Nations (United Nations Statistical Division, 2002).The complexity of those services was then computed as the average complexity of industries related to them.

[13]Major industry groups are defined as the lowest industrial level of disaggregation provided by ISIC 3.1 (1-digit level). They are: A- Agriculture, hunting and forestry; B- Fishing; C- Mining and quarrying; D- Manufacturing; E- Electricity, gas and water supply; F- Construction; G- Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods; H- Hotels and restaurants; I- Transport, storage and communications; J- Financial intermediation; K- Real estate, renting and business activities; L- Public administration and defence; compulsory social security; M- Education; N- Health and social work; O- Other community, social and personal service activities; P- Activities of private households as employers and undifferentiated production activities of private households; Q- Extraterritorial organizations and bodies.

[14]Note that the figures on informal employment should be considered as a lower-bound estimation, since they exclude household agricultural activities, which are not included in the IBES survey (see section 3.1.2)

[15]See Appendix B and D for more detail on ICT-related industries.

[16]Note that the aggregate employment figures for the household sector may include some double counting of employees that work on more than one activity since the aggregate figures sum employees (who cannot be uniquely identified) working on agricultural plots and in non-farming enterprises, divided by sector of activity.

A   Treemaps
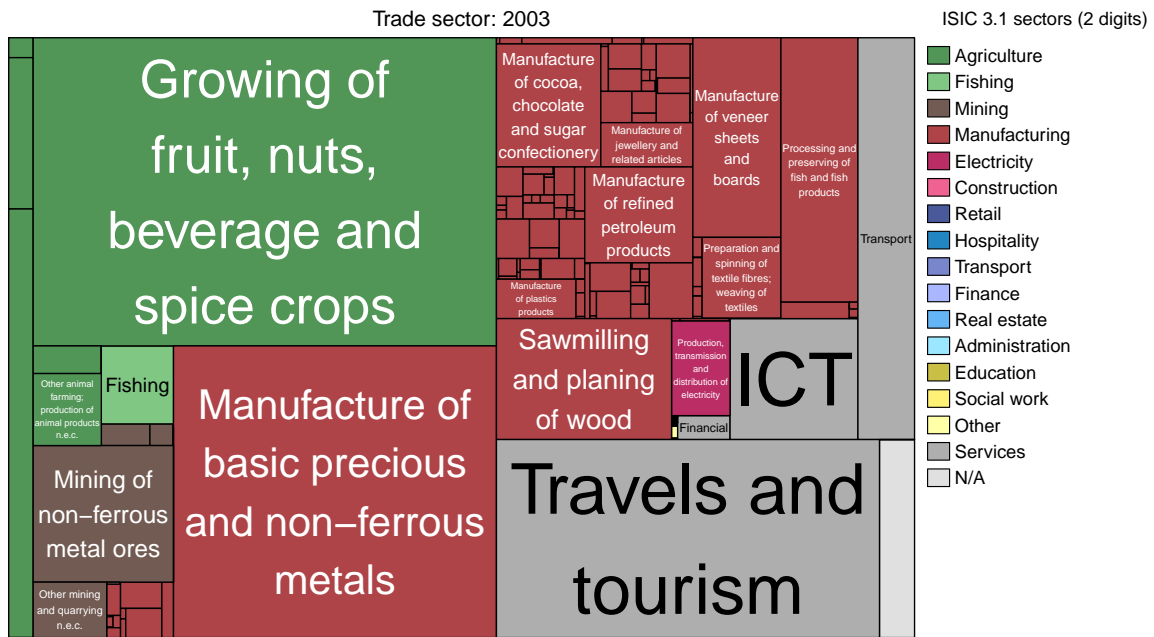
Figure 9: Exported goods and services by Ghana - ISIC sectors (2003)
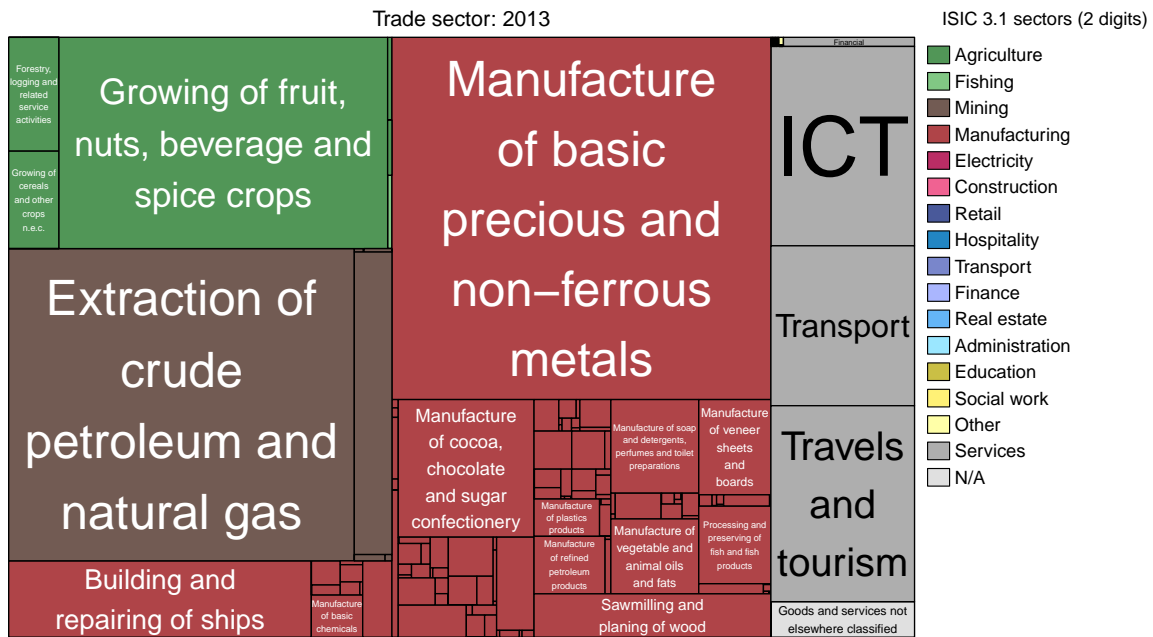
Figure 10: Exported goods and services by Ghana - ISIC sectors (2013)

Figure 11: Proportion of formal employment in Ghana by ISIC sector - manufacturing and mining (2003)
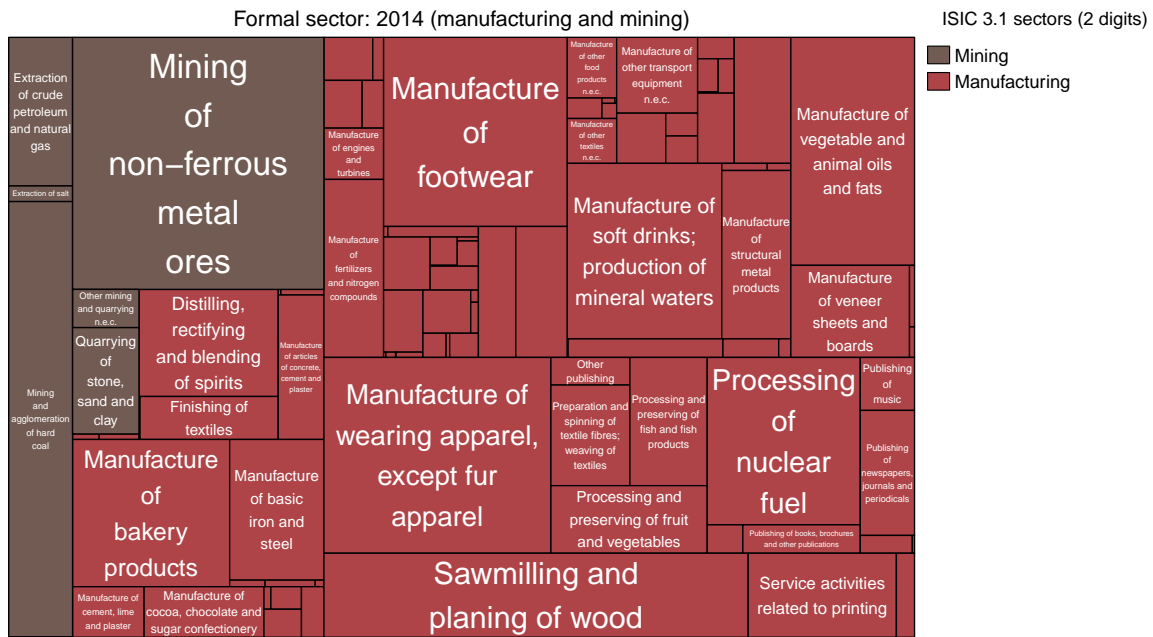
Figure 12: Proportion of formal employment in Ghana - manufacturing and mining (2014)
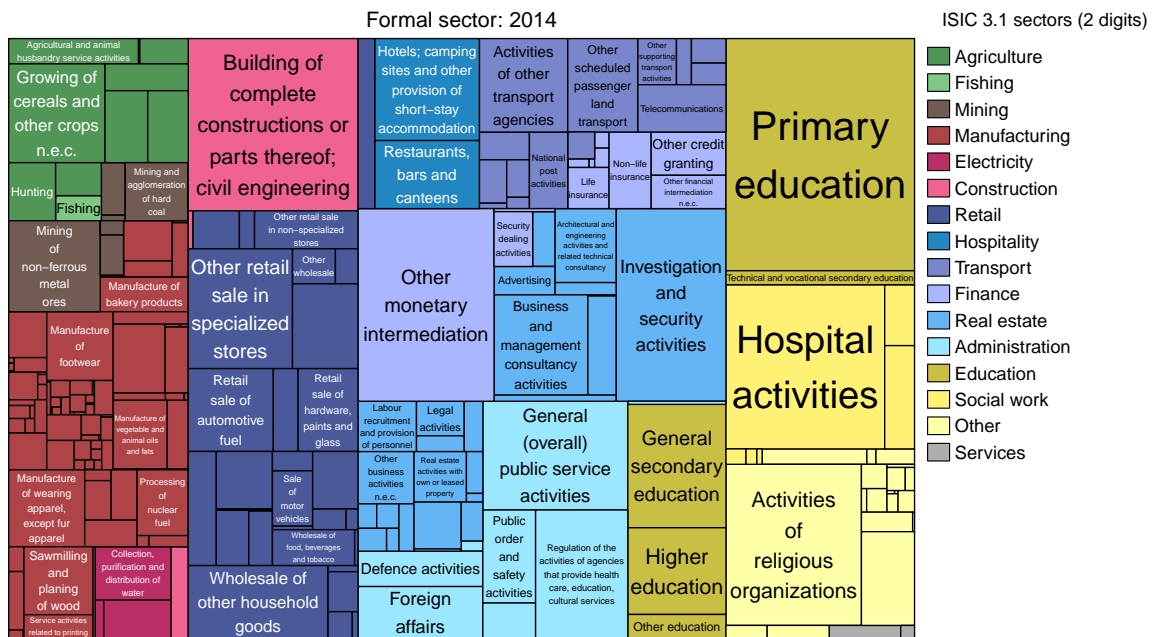
Figure 13: Proportion of formal employment in Ghana by ISIC sector (2014)
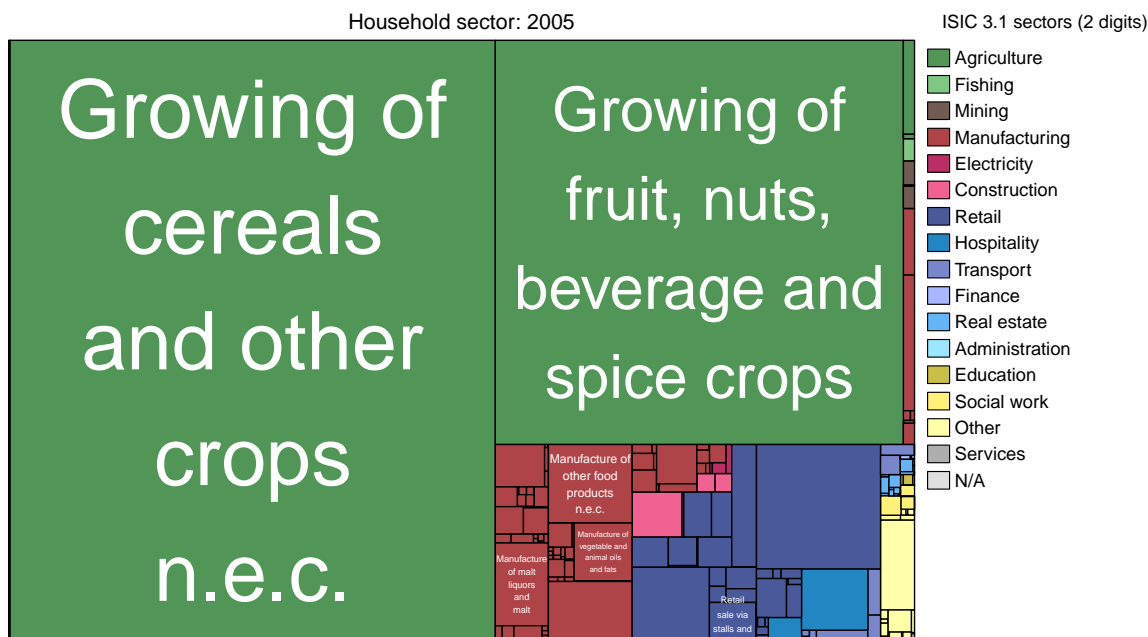
Figure 14: Proportion of employment in household enterprises by ISIC sectors - GLSS (2005)

Figure 15: Proportion of employment in household enterprises by ISIC sectors (agriculture excluded) - GLSS (2005)
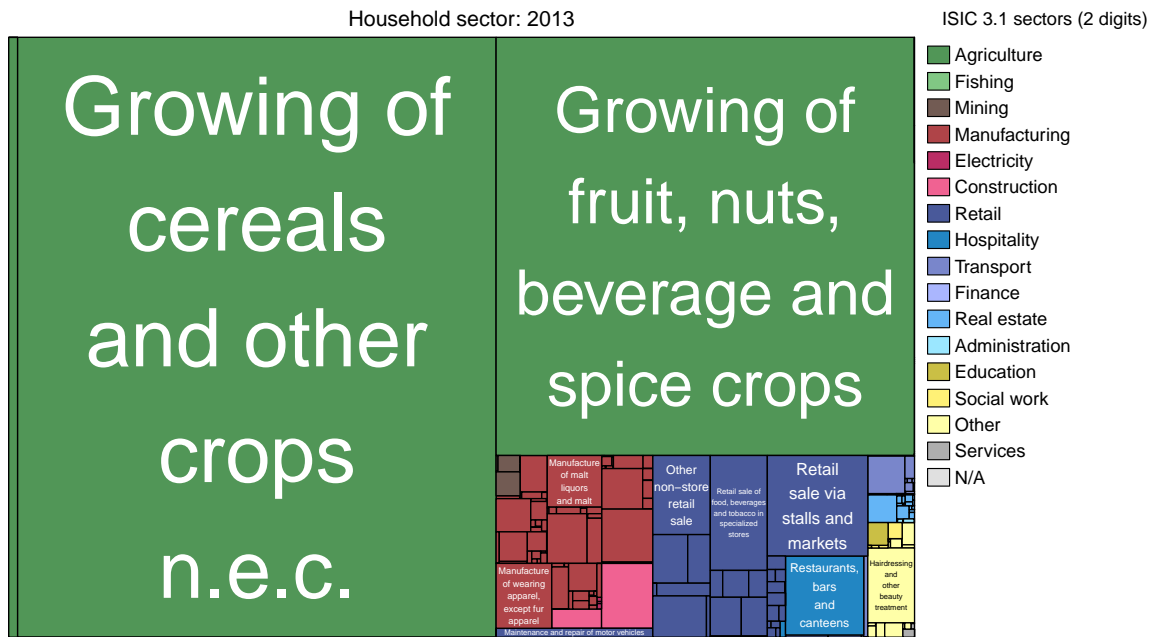
Figure 16: Proportion of employment in household enterprises by ISIC sectors - GLSS (2013)
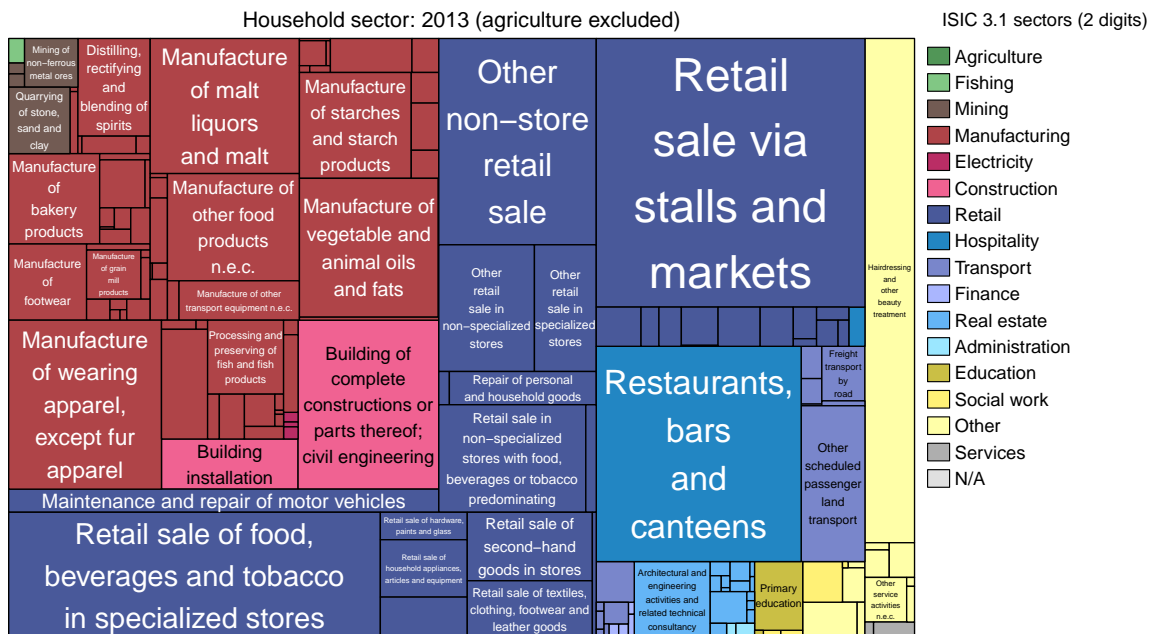
Figure 17: Proportion of employment in household non-farming enterprises by ISIC sectors (agriculture excluded) - GLSS (2013)

B Tradable services: correspondence table

Table 4: Correspondence between Harmonised System tradable services and ISIC industries

Tradable services label (HS)	ISIC corresponding industries
ICT	4-digit ISIC codes: 3000, 3130, 3210, 3220, 3230, 3312, 3313, 5150, 7123, 6420, 7210, 7221, 7229, 7230, 7240, 7250, 7290
Financial	All 4-digit ISIC industries in "Financial intermediatio" (1-digit label)
Transport	All 4-digit ISIC industries in "Transport, storage and communication" (1-digit label)
Travels and tourism	4-digit ISIC code: 6304

Note: Please refer to Appendix B for the full ISIC labels

C   Validating the complexity and fitness framework

To provide empirical support for the complexity and fitness framework used for our analysis, we compute the two-way correlation between fitness and a widely used proxy for economic development at the subnational level: nighttime luminosity (Alesina, Michalopoulos, & Papaioannou, 2016; Elvidge et al., 2012; Weidmann & Schutte, 2017). Building on evidence that measures of economic complexity (using trade data) are good predictors of national growth (Cristelli et al., 2017; Tacchella et al., 2018), we assume that the "fittest" districts are specialised in more sophisticated industries, which require more capabilities and lead to higher economic output.

Figure 18 plots the correlation between district fitness, calculated as described in Section 3.2, and district average night time luminosity. Nightlights satellite imagery was made available by the Earth Observation Group and was collected as part of the VIIRS time series (Elvidge et al., 2017) and was used to produce a high-quality global Nighttime Light map. The data comes in a raster of 15 arc seconds resolution (approx. 0.5 km at the Equator). Superimposing Ghana's districts coordinates on the raster for 2014 (the year in which the IBES data were collected), the nightlight data were averaged by district to create a measure of average nighttime luminosity.
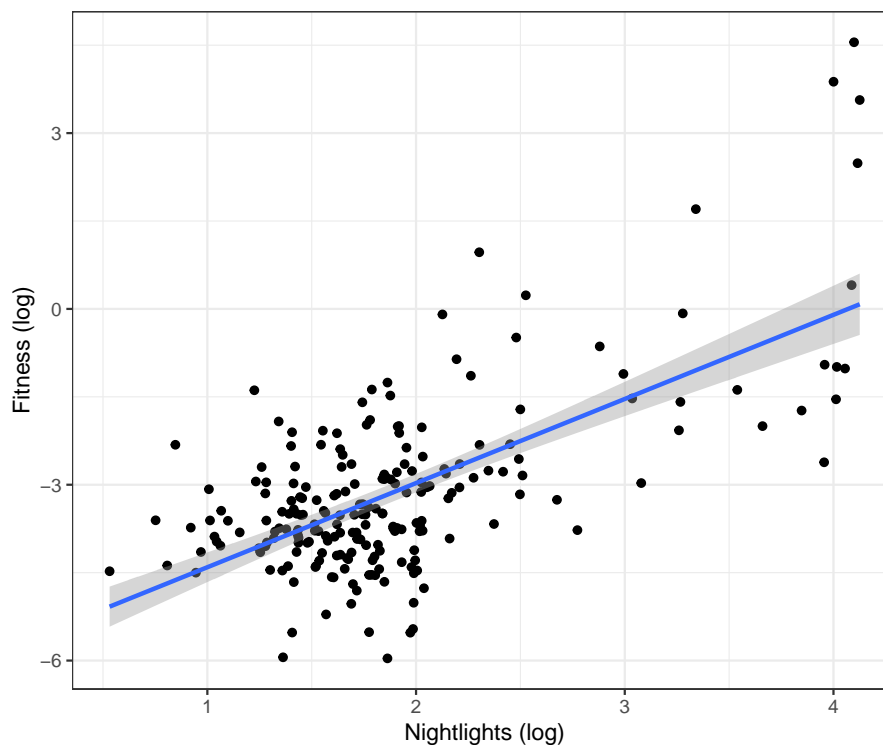
Figure 18: Log-log correlation between Ghanaian districts' fitness and nighttime luminosity.

The positive slope of the fitted line between fitness and average nightlights (Figure 18) shows that there is a positive relation between economic fitness and economic development in Ghana's districts, as predicted at the country level. To ensure that the results are

not driven by higher population density in districts engaged in more diversified economic activities, Table 5 presents the results of an Ordinary Least Squares regression of fitness on nightlight luminosity, without (1) and with (2) the district (log) population density as covariate. Neither the results nor the R-squared change substantially with the introduction of population density. The coefficient of the log of nightlights remains positive and statistically significant, although the point estimate is slightly smaller after controlling for population. Of course, these results do not provide evidence that the ICI, our measure of industry complexity, causes higher economic development in a district (measured by nightlight intensity).

Table 5: Correlation between district fitness and nighttime luminosity

	Dependent variable:	
	Fitness (log)	
	(1)	(2)
Avg. Nightlights (log)	1.436***	1.351***
	(0.188)	(0.184)
Pop. density (log)		0.056
		(0.051)
Constant	−5.843***	−5.936***
	(0.328)	(0.360)
Observations	216	216
R^2	0.428	0.431
Adjusted R^2	0.425	0.426
Residual Std. Error	1.158 (df = 214)	1.157 (df = 213)
F Statistic	159.893*** (df = 1; 214)	80.632*** (df = 2; 213)

Note: All coefficients are estimated using OLS. Observations are Ghanaian districts. Heteroskedasticity robust s.e. in parentheses: *p<0.1; **p<0.05; ***p<0.01.

D Final dataset

Table 6: Final dataset

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
0111	Growing of cereals and other crops n.e.c.	Agriculture	1.93	0.90	0.00	1.75	53.51	53.09	-6.91
0112	Growing of vegetables, horticultural specialties and nursery products	Agriculture	0.35	0.07	0.00	0.54	0.19	0.00	-4.97
0113	Growing of fruit, nuts, beverage and spice crops	Agriculture	26.28	12.78	0.00	0.57	30.32	32.34	-6.81
0121	Farming of cattle, sheep, goats, horses, asses, mules and hinnies; dairy farming	Agriculture	0.09	0.00	0.00	0.01	0.02	0.00	-7.38
0122	Other animal farming; production of animal products n.e.c.	Agriculture	0.90	0.04	0.00	0.28	0.01	0.00	-7.38
0130	Growing of crops combined with farming of animals (mixed farming)	Agriculture	0.00	0.00	0.00	0.41	0.00	0.00	-5.13
0140	Agricultural and animal husbandry service activities	Agriculture	0.00	0.00	0.00	0.60	0.00	0.00	-7.59
0150	Hunting	Agriculture	0.00	0.00	0.00	0.50	0.00	0.00	-6.08
0200	Forestry, logging and related service activities	Agriculture	0.68	1.05	0.00	0.23	0.13	0.99	-7.08
0501	Fishing	Fishing	1.04	0.06	0.00	0.21	0.05	0.01	-5.25
1010	Mining and agglomeration of hard coal	Mining	0.00	0.00	0.00	0.67	0.00	0.01	-4.54
1020	Mining and agglomeration of lignite	Mining	0.00	0.00	0.00	NA	0.00	0.00	NA
1030	Extraction and agglomeration of peat	Mining	0.00	0.00	0.00	NA	0.00	0.00	NA
1110	Extraction of crude petroleum and natural gas	Mining	0.19	19.86	0.00	0.23	0.00	0.00	-4.22
1200	Mining of uranium and thorium ores	Mining	0.00	0.00	0.00	0.00	0.00	0.00	4.70
1310	Mining of iron ores	Mining	0.00	0.00	0.00	0.00	0.00	0.00	2.43
1320	Mining of non-ferrous metal ores	Mining	3.53	2.10	4.80	1.53	0.00	0.07	-5.81
1322	Bauxite mining	Mining	0.00	0.00	0.16	NA	0.00	0.00	NA
1323	Manganese mining	Mining	0.00	0.00	0.24	NA	0.00	0.00	NA
1410	Quarrying of stone, sand and clay	Mining	0.00	0.01	0.50	0.17	0.05	0.11	-6.04
1421	Mining of chemical and fertilizer minerals	Mining	0.00	0.02	0.00	NA	0.00	0.00	NA
1422	Extraction of salt	Mining	0.09	0.01	0.72	0.02	0.00	0.00	-4.88
1429	Other mining and quarrying n.e.c.	Mining	0.75	0.04	0.32	0.06	0.00	0.00	-3.92
1511	Production, processing and preserving of meat and meat products	Manufacturing	0.01	0.01	0.18	0.02	0.06	0.03	-6.99
1512	Processing and preserving of fish and fish products	Manufacturing	3.75	1.03	1.61	0.24	0.29	0.15	-6.03
1513	Processing and preserving of fruit and vegetables	Manufacturing	0.21	0.12	0.55	0.26	0.00	0.01	-5.98
1514	Manufacture of vegetable and animal oils and fats	Manufacturing	0.45	1.21	1.72	0.68	0.62	0.50	-7.08
1520	Manufacture of dairy products	Manufacturing	0.14	0.03	0.62	0.05	0.02	0.01	-4.34
1531	Manufacture of grain mill products	Manufacturing	0.18	0.15	1.95	0.06	0.12	0.07	-8.64

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
1532	Manufacture of starches and starch products	Manufacturing	0.17	0.22	0.04	0.01	0.03	0.31	-8.02
1533	Manufacture of prepared animal feeds	Manufacturing	0.00	0.00	0.05	0.02	0.01	0.00	-5.35
1541	Manufacture of bakery products	Manufacturing	0.02	0.01	2.61	0.56	0.38	0.21	-6.57
1542	Manufacture of sugar	Manufacturing	0.02	0.00	0.00	0.00	0.00	0.00	-2.05
1543	Manufacture of cocoa, chocolate and sugar confectionery	Manufacturing	2.36	3.44	0.50	0.15	0.00	0.01	-5.44
1544	Manufacture of macaroni, noodles, couscous and similar farinaceous products	Manufacturing	0.02	0.04	0.00	NA	0.00	0.00	-1.51
1549	Manufacture of other food products n.e.c.	Manufacturing	0.16	0.23	0.22	0.07	1.21	0.37	-5.82
1551	Distilling, rectifying and blending of spirits	Manufacturing	0.01	0.13	0.66	0.36	0.28	0.18	-6.89
1552	Manufacture of wines	Manufacturing	0.02	0.01	0.00	NA	0.03	0.00	NA
1553	Manufacture of malt liquors and malt	Manufacturing	0.01	0.00	1.35	0.05	0.81	0.52	-7.11
1554	Manufacture of soft drinks; production of mineral waters	Manufacturing	0.03	0.02	1.27	0.66	0.00	0.02	-6.85
1600	Manufacture of tobacco products	Manufacturing	0.05	0.01	0.13	NA	0.00	0.00	NA
1711	Preparation and spinning of textile fibres; weaving of textiles	Manufacturing	1.17	0.10	1.43	0.19	0.10	0.13	-6.91
1712	Finishing of textiles	Manufacturing	0.00	0.00	1.49	0.14	0.01	0.02	-4.79
1721	Manufacture of made-up textile articles, except apparel	Manufacturing	0.03	0.02	0.05	0.00	0.01	0.01	-5.96
1722	Manufacture of carpets and rugs	Manufacturing	0.00	0.00	0.00	0.00	0.00	0.01	1.10
1723	Manufacture of cordage, rope, twine and netting	Manufacturing	0.00	0.00	0.12	0.02	0.01	0.00	-3.82
1729	Manufacture of other textiles n.e.c.	Manufacturing	0.01	0.00	0.01	0.05	0.00	0.01	-5.12
1730	Manufacture of knitted and crocheted fabrics and articles	Manufacturing	0.14	0.00	0.01	0.00	0.04	0.01	-6.57
1810	Manufacture of wearing apparel, except fur apparel	Manufacturing	0.05	0.03	23.77	1.08	0.90	0.67	-7.73
1820	Dressing and dyeing of fur; manufacture of articles of fur	Manufacturing	0.00	0.00	0.01	0.00	0.01	0.00	-4.99
1911	Tanning and dressing of leather	Manufacturing	0.02	0.00	0.00	NA	0.01	0.00	NA
1912	Manufacture of luggage, handbags and the like	Manufacturing	0.01	0.01	0.06	0.01	0.00	0.00	-6.39
1920	Manufacture of footwear	Manufacturing	0.04	0.04	1.55	0.84	0.05	0.15	-4.95
2010	Sawmilling and planing of wood	Manufacturing	3.90	1.89	8.62	0.86	0.03	0.01	-7.03
2021	Manufacture of veneer sheets and boards	Manufacturing	3.23	1.26	4.66	0.26	0.01	0.00	-4.31
2022	Manufacture of builders' carpentry and joinery	Manufacturing	0.03	0.01	1.43	0.01	0.08	0.06	-8.16
2023	Manufacture of wooden containers	Manufacturing	0.00	0.00	0.19	NA	0.01	0.01	-6.39
2029	Manufacture of other products of wood	Manufacturing	0.18	0.09	0.49	NA	0.11	0.00	NA
2101	Manufacture of pulp, paper and paperboard	Manufacturing	0.02	0.01	0.02	0.00	0.00	0.00	-1.99
2102	Manufacture of corrugated paper and paperboard	Manufacturing	0.06	0.04	0.17	0.03	0.00	0.00	-1.16
2109	Manufacture of other articles of paper and paperboard	Manufacturing	0.01	0.00	0.29	NA	0.01	0.00	NA

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
2211	Publishing of books, brochures and other publications	Manufacturing	0.01	0.00	0.01	0.08	0.01	0.00	-4.24
2212	Publishing of newspapers, journals and periodicals	Manufacturing	0.00	0.00	0.43	0.16	0.00	0.00	0.11
2213	Publishing of music	Manufacturing	0.00	0.00	0.01	0.07	0.00	0.00	-3.98
2219	Other publishing	Manufacturing	0.00	0.00	0.04	0.05	0.01	0.00	-6.19
2221	Printing	Manufacturing	0.00	0.00	1.77	NA	0.00	0.00	NA
2222	Service activities related to printing	Manufacturing	0.00	0.00	0.25	0.30	0.02	0.01	-4.38
2230	Reproduction of recorded media	Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	-4.87
2310	Manufacture of coke oven products	Manufacturing	0.00	0.00	0.00	0.00	0.01	0.00	-3.22
2320	Manufacture of refined petroleum products	Manufacturing	1.91	0.75	0.40	NA	0.00	0.00	NA
2330	Processing of nuclear fuel	Manufacturing	0.00	0.00	0.00	0.62	0.00	0.03	-5.20
2411	Manufacture of basic chemicals	Manufacturing	0.19	0.40	0.16	NA	0.00	0.00	NA
2412	Manufacture of fertilizers and nitrogen compounds	Manufacturing	0.10	0.19	0.01	0.26	0.00	0.00	-2.39
2413	Manufacture of plastics in primary forms and of synthetic rubber	Manufacturing	0.04	0.01	0.12	0.02	0.00	0.00	-3.27
2421	Manufacture of pesticides and other agrochemical products	Manufacturing	0.01	0.02	0.03	0.02	0.00	0.00	-2.41
2422	Manufacture of paints, varnishes and similar coatings	Manufacturing	0.04	0.10	0.32	0.06	0.00	0.00	0.58
2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products	Manufacturing	0.13	0.05	1.04	NA	0.01	0.00	NA
2424	Manufacture of soap and detergents, perfumes and toilet preparations	Manufacturing	0.21	1.51	1.40	0.17	0.05	0.07	-6.28
2429	Manufacture of other chemical products n.e.c.	Manufacturing	0.08	0.16	0.02	0.02	0.00	0.00	-4.49
2430	Manufacture of man-made fibres	Manufacturing	0.01	0.01	0.25	NA	0.00	0.00	-1.08
2511	Manufacture of rubber tyres and tubes	Manufacturing	0.05	0.06	0.00	0.06	0.00	0.00	-1.13
2519	Manufacture of other rubber products	Manufacturing	0.01	0.06	1.05	0.00	0.01	0.00	-2.72
2520	Manufacture of plastics products	Manufacturing	0.58	0.45	1.75	0.02	0.01	0.02	-6.80
2610	Manufacture of glass and glass products	Manufacturing	0.09	0.32	0.02	0.02	0.01	0.00	-6.37
2691	Manufacture of non-structural non-refractory ceramic ware	Manufacturing	0.02	0.00	0.14	0.01	0.07	0.03	-6.47
2692	Manufacture of refractory ceramic products	Manufacturing	0.00	0.00	0.09	0.01	0.02	0.00	-5.69
2693	Manufacture of structural non-refractory clay and ceramic products	Manufacturing	0.02	0.01	0.25	NA	0.01	0.00	NA
2694	Manufacture of cement, lime and plaster	Manufacturing	0.06	0.17	0.31	0.09	0.00	0.00	-3.42
2695	Manufacture of articles of concrete, cement and plaster	Manufacturing	0.01	0.05	2.48	0.16	0.04	0.01	-6.07
2696	Cutting, shaping and finishing of stone	Manufacturing	0.00	0.00	0.00	NA	0.14	0.00	-3.09
2699	Manufacture of other non-metallic mineral products n.e.c.	Manufacturing	0.00	0.00	0.04	0.00	0.00	0.00	-4.34
2710	Manufacture of basic iron and steel	Manufacturing	0.12	0.41	0.62	0.32	0.00	0.01	-4.77

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
2720	Manufacture of basic precious and non-ferrous metals	Manufacturing	17.34	25.27	0.37	NA	0.00	0.00	NA
2731	Casting of iron and steel	Manufacturing	0.00	0.00	0.27	NA	0.00	0.00	NA
2732	Casting of non-ferrous metals	Manufacturing	0.00	0.00	0.00	0.01	0.00	0.00	-1.65
2811	Manufacture of structural metal products	Manufacturing	0.02	0.03	3.41	0.28	0.01	0.02	-6.46
2812	Manufacture of tanks, reservoirs and containers of metal	Manufacturing	0.01	0.01	0.24	0.07	0.00	0.00	-6.89
2813	Manufacture of steam generators, except central heating hot water boilers	Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	-3.52
2891	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	-6.88
2892	Treatment and coating of metals	Manufacturing	0.00	0.00	0.02	0.04	0.05	0.03	-7.56
2893	Manufacture of cutlery, hand tools and general hardware	Manufacturing	0.15	0.09	0.35	0.03	0.02	0.01	-7.22
2899	Manufacture of other fabricated metal products n.e.c.	Manufacturing	0.24	0.26	2.77	0.16	0.01	0.02	-5.12
2911	Manufacture of engines and turbines	Manufacturing	0.18	0.03	0.00	0.07	0.00	0.02	-6.53
2912	Manufacture of pumps, compressors, taps and valves	Manufacturing	0.04	0.07	0.00	0.00	0.00	0.00	2.97
2913	Manufacture of bearings, gears, gearing and driving elements	Manufacturing	0.00	0.01	0.00	NA	0.00	0.00	-1.73
2914	Manufacture of ovens, furnaces and furnace burners	Manufacturing	0.00	0.00	0.03	0.00	0.00	0.00	-3.19
2915	Manufacture of lifting and handling equipment	Manufacturing	0.02	0.40	0.01	0.00	0.00	0.01	3.41
2919	Manufacture of other general-purpose machinery	Manufacturing	0.06	0.04	0.00	0.02	0.00	0.00	-3.43
2921	Manufacture of agricultural and forestry machinery	Manufacturing	0.03	0.02	0.42	0.01	0.01	0.00	-6.16
2922	Manufacture of machine tools	Manufacturing	0.07	0.07	0.09	0.03	0.00	0.00	-5.76
2923	Manufacture of machinery for metallurgy	Manufacturing	0.00	0.00	0.01	0.00	0.00	0.00	0.06
2924	Manufacture of machinery for mining, quarrying and construction	Manufacturing	0.08	0.64	0.04	0.00	0.00	0.00	-4.10
2925	Manufacture of machinery for food, beverage and tobacco processing	Manufacturing	0.04	0.05	0.29	0.06	0.01	0.00	-5.26
2926	Manufacture of machinery for textile, apparel and leather production	Manufacturing	0.01	0.00	0.00	0.00	0.00	0.00	-2.42
2927	Manufacture of weapons and ammunition	Manufacturing	0.00	0.00	0.04	0.00	0.00	0.00	-5.65
2929	Manufacture of other special-purpose machinery	Manufacturing	0.06	0.05	0.01	0.01	0.00	0.00	-4.24
2930	Manufacture of domestic appliances n.e.c.	Manufacturing	0.07	0.03	0.00	0.01	0.00	0.00	-5.02
3000	Manufacture of office, accounting and computing machinery	Manufacturing	0.03	0.02	0.00	0.00	0.00	0.00	-0.25

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
3110	Manufacture of electric motors, generators and transformers	Manufacturing	0.01	0.05	0.00	0.02	0.00	0.00	-0.42
3120	Manufacture of electricity distribution and control apparatus	Manufacturing	0.03	0.10	0.00	NA	0.00	0.00	NA
3130	Manufacture of insulated wire and cable	Manufacturing	0.00	0.01	0.09	0.02	0.00	0.00	-4.00
3140	Manufacture of accumulators, primary cells and primary batteries	Manufacturing	0.02	0.05	0.00	NA	0.00	0.00	-1.82
3150	Manufacture of electric lamps and lighting equipment	Manufacturing	0.02	0.01	0.00	0.04	0.00	0.00	-3.29
3190	Manufacture of other electrical equipment n.e.c.	Manufacturing	0.01	0.02	0.00	0.12	0.01	0.01	-3.93
3210	Manufacture of electronic valves and tubes and other electronic components	Manufacturing	0.00	0.00	0.00	NA	0.00	0.00	NA
3220	Manufacture of television, telephone and radio transmitters	Manufacturing	0.01	0.07	0.00	0.01	0.00	0.02	-7.71
3230	Manufacture of television and radio receivers	Manufacturing	0.05	0.06	0.06	0.03	0.01	0.03	-7.35
3311	Manufacture of medical and surgical equipment	Manufacturing	0.02	0.14	0.01	NA	0.00	0.00	NA
3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating	Manufacturing	0.03	0.09	0.00	NA	0.00	0.00	NA
3313	Manufacture of industrial process control equipment	Manufacturing	0.00	0.00	0.00	NA	0.00	0.00	NA
3320	Manufacture of optical instruments and photographic equipment	Manufacturing	0.00	0.01	0.00	NA	0.00	0.00	NA
3330	Manufacture of watches and clocks	Manufacturing	0.03	0.00	0.00	0.01	0.00	0.01	-5.28
3410	Manufacture of motor vehicles	Manufacturing	0.09	0.06	0.00	0.00	0.02	0.00	-4.04
3420	Manufacture of bodies (coachwork) for motor vehicles	Manufacturing	0.10	0.07	0.31	0.01	0.01	0.00	-4.70
3430	Manufacture of parts and accessories for motor vehicles	Manufacturing	0.03	0.04	0.05	NA	0.00	0.00	NA
3511	Building and repairing of ships	Manufacturing	0.08	4.25	0.06	0.00	0.00	0.01	-6.29
3512	Building and repairing of pleasure and sporting boats	Manufacturing	0.00	0.00	0.00	NA	0.00	0.00	-5.07
3520	Manufacture of railway and tramway locomotives and rolling stock	Manufacturing	0.00	0.00	0.00	NA	0.00	0.00	NA
3530	Manufacture of aircraft and spacecraft	Manufacturing	0.20	0.07	0.00	NA	0.00	0.00	NA
3591	Manufacture of motorcycles	Manufacturing	0.10	0.01	0.00	NA	0.03	0.00	-2.16
3592	Manufacture of bicycles and invalid carriages	Manufacturing	0.03	0.01	0.01	NA	0.02	0.00	-1.51
3599	Manufacture of other transport equipment n.e.c.	Manufacturing	0.01	0.00	0.05	0.15	0.00	0.12	-7.80
3610	Manufacture of furniture	Manufacturing	0.21	0.03	12.75	0.00	0.14	0.01	-5.03
3691	Manufacture of jewellery and related articles	Manufacturing	0.75	0.03	0.13	NA	0.03	0.00	NA
3692	Manufacture of musical instruments	Manufacturing	0.03	0.00	0.03	0.01	0.00	0.01	-5.16

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
3693	Manufacture of sports goods	Manufacturing	0.00	0.00	0.00	NA	0.00	0.00	NA
3694	Manufacture of games and toys	Manufacturing	0.00	0.00	0.02	NA	0.00	0.00	4.02
3699	Other manufacturing n.e.c.	Manufacturing	0.03	0.01	0.48	NA	0.07	0.00	NA
3710	Recycling of metal waste and scrap	Manufacturing	0.00	0.00	0.00	0.02	0.00	0.00	-3.15
4010	Production, transmission and distribution of electricity	Electricity	1.02	0.00	0.00	0.47	0.03	0.00	-7.04
4020	Manufacture of gas; distribution of gaseous fuels through mains	Electricity	0.00	0.00	0.00	0.06	0.03	0.00	-5.45
4100	Collection, purification and distribution of water	Electricity	0.00	0.00	0.00	0.74	0.01	0.00	-6.68
4510	Site preparation	Construction	0.00	0.00	0.00	0.03	0.01	0.00	-5.75
4520	Building of complete constructions or parts thereof; civil engineering	Construction	0.00	0.00	0.00	5.38	0.41	0.62	-5.38
4530	Building installation	Construction	0.00	0.00	0.00	0.29	0.06	0.18	-6.31
4540	Building completion	Construction	0.00	0.00	0.00	NA	0.06	0.00	NA
5010	Sale of motor vehicles	Retail	0.00	0.00	0.00	0.41	0.01	0.02	-1.77
5020	Maintenance and repair of motor vehicles	Retail	0.00	0.00	0.00	0.33	0.23	0.26	-6.53
5030	Sale of motor vehicle parts and accessories	Retail	0.00	0.00	0.00	0.14	0.03	0.05	-5.73
5040	Sale, maintenance and repair of motorcycles and related parts and accessories	Retail	0.00	0.00	0.00	0.03	0.04	0.02	-8.38
5050	Retail sale of automotive fuel	Retail	0.00	0.00	0.00	1.30	0.00	0.03	-7.84
5110	Wholesale on a fee or contract basis	Retail	0.00	0.00	0.00	0.52	0.01	0.01	-6.23
5121	Wholesale of agricultural raw materials and live animals	Retail	0.00	0.00	0.00	0.48	0.22	0.04	-7.58
5122	Wholesale of food, beverages and tobacco	Retail	0.00	0.00	0.00	0.54	0.09	0.04	-6.64
5131	Wholesale of textiles, clothing and footwear	Retail	0.00	0.00	0.00	0.03	0.02	0.01	-5.12
5139	Wholesale of other household goods	Retail	0.00	0.00	0.00	1.87	0.00	0.03	-3.62
5141	Wholesale of solid, liquid and gaseous fuels and related products	Retail	0.00	0.00	0.00	0.12	0.01	0.01	-6.55
5142	Wholesale of metals and metal ores	Retail	0.00	0.00	0.00	0.02	0.00	0.00	-6.72
5143	Wholesale of construction materials	Retail	0.00	0.00	0.00	NA	0.00	0.00	NA
5149	Wholesale of other intermediate products, waste and scrap	Retail	0.00	0.00	0.00	0.03	0.01	0.02	-5.96
5151	Wholesale of computers, computer peripheral equipment and software	Retail	0.00	0.00	0.00	0.13	0.00	0.00	-2.86
5152	Wholesale of electronic and telecommunications parts and equipment	Retail	0.00	0.00	0.00	0.04	0.01	0.00	-5.32
5159	Wholesale of other machinery, equipment and supplies	Retail	0.00	0.00	0.00	0.22	0.00	0.00	-5.39
5190	Other wholesale	Retail	0.00	0.00	0.00	0.28	0.01	0.01	-3.25
5211	Retail sale in non-specialized stores with food, beverages or tobacco predominating	Retail	0.00	0.00	0.00	1.02	0.56	0.41	-8.55
5219	Other retail sale in non-specialized stores	Retail	0.00	0.00	0.00	0.72	0.20	0.31	-7.81

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
5220	Retail sale of food, beverages and tobacco in specialized stores	Retail	0.00	0.00	0.00	0.38	1.03	1.21	-7.92
0523	Other retail trade of new goods in specialized stores	Retail	0.00	0.00	0.00	NA	0.01	0.00	NA
5231	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles	Retail	0.00	0.00	0.00	0.59	0.12	0.09	-7.73
5232	Retail sale of textiles, clothing, footwear and leather goods	Retail	0.00	0.00	0.00	0.33	0.32	0.19	-6.55
5233	Retail sale of household appliances, articles and equipment	Retail	0.00	0.00	0.00	0.59	0.05	0.13	-6.80
5234	Retail sale of hardware, paints and glass	Retail	0.00	0.00	0.00	0.91	0.06	0.06	-6.72
5239	Other retail sale in specialized stores	Retail	0.00	0.00	0.00	2.30	0.15	0.20	-6.64
5240	Retail sale of second-hand goods in stores	Retail	0.00	0.00	0.00	0.01	0.08	0.22	-6.10
5251	Retail sale via mail order houses	Retail	0.00	0.00	0.00	0.00	0.00	0.01	-4.85
5252	Retail sale via stalls and markets	Retail	0.00	0.00	0.00	0.24	2.84	1.87	-7.09
5259	Other non-store retail sale	Retail	0.00	0.00	0.00	0.11	0.17	0.84	-7.68
5260	Repair of personal and household goods	Retail	0.00	0.00	0.00	0.15	0.19	0.13	-7.93
5510	Hotels; camping sites and other provision of short-stay accommodation	Hospitality	0.00	0.00	0.00	1.97	0.14	0.02	-5.98
5520	Restaurants, bars and canteens	Hospitality	0.00	0.00	0.00	1.31	0.75	1.14	-8.45
6010	Transport via railways	Transport	0.00	0.00	0.00	0.13	0.00	0.00	-3.04
6021	Other scheduled passenger land transport	Transport	0.00	0.00	0.00	1.20	0.06	0.26	-6.56
6022	Other non-scheduled passenger land transport	Transport	0.00	0.00	0.00	NA	0.11	0.00	NA
6023	Freight transport by road	Transport	0.00	0.00	0.00	0.16	0.00	0.06	-4.76
6030	Transport via pipelines	Transport	0.00	0.00	0.00	0.00	0.00	0.00	-2.04
6110	Sea and coastal water transport	Transport	0.00	0.00	0.00	0.16	0.00	0.00	1.47
6120	Inland water transport	Transport	0.00	0.00	0.00	0.05	0.09	0.00	-4.07
6210	Scheduled air transport	Transport	0.00	0.00	0.00	0.13	0.00	0.00	-1.85
6301	Cargo handling	Transport	0.00	0.00	0.00	0.22	0.01	0.01	-5.15
6302	Storage and warehousing	Transport	0.00	0.00	0.00	0.14	0.00	0.00	-6.64
6303	Other supporting transport activities	Transport	0.00	0.00	0.00	0.33	0.07	0.04	-1.41
6304	Activities of travel agencies and tour operators	Transport	0.00	0.00	0.00	0.25	0.01	0.00	-5.06
6309	Activities of other transport agencies	Transport	0.00	0.00	0.00	1.52	0.01	0.02	-4.87
6411	National post activities	Transport	0.00	0.00	0.00	0.54	0.00	0.01	-6.23
6412	Courier activities other than national post activities	Transport	0.00	0.00	0.00	0.03	0.00	0.00	-4.42
6420	Telecommunications	Transport	0.00	0.00	0.00	0.77	0.07	0.01	-3.52
6511	Central banking	Finance	0.00	0.00	0.00	0.04	0.00	0.00	-5.74
6519	Other monetary intermediation	Finance	0.00	0.00	0.00	4.82	0.00	0.00	-6.66
6591	Financial leasing	Finance	0.00	0.00	0.00	0.05	0.00	0.00	-5.50
6592	Other credit granting	Finance	0.00	0.00	0.00	0.60	0.00	0.00	-6.51
6599	Other financial intermediation n.e.c.	Finance	0.00	0.00	0.00	0.46	0.00	0.00	-5.60
6601	Life insurance	Finance	0.00	0.00	0.00	0.31	0.00	0.00	-5.33

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
6602	Pension funding	Finance	0.00	0.00	0.00	0.03	0.00	0.00	-5.91
6603	Non-life insurance	Finance	0.00	0.00	0.00	0.59	0.00	0.00	-7.06
6711	Administration of financial markets	Finance	0.00	0.00	0.00	0.01	0.00	0.00	-3.95
6712	Security dealing activities	Finance	0.00	0.00	0.00	0.39	0.00	0.00	-2.75
6719	Activities auxiliary to financial intermediation n.e.c.	Finance	0.00	0.00	0.00	NA	0.01	0.00	NA
6720	Activities auxiliary to insurance and pension funding	Finance	0.00	0.00	0.00	0.03	0.00	0.00	-5.05
7010	Real estate activities with own or leased property	Real estate	0.00	0.00	0.00	0.49	0.01	0.00	-3.72
7020	Real estate activities on a fee or contract basis	Real estate	0.00	0.00	0.00	0.13	0.00	0.00	-4.68
7111	Renting of land transport equipment	Real estate	0.00	0.00	0.00	0.13	0.00	0.00	-5.47
7121	Renting of agricultural machinery and equipment	Real estate	0.00	0.00	0.00	NA	0.01	0.00	NA
7130	Renting of personal and household goods n.e.c.	Real estate	0.00	0.00	0.00	0.03	0.00	0.01	-7.01
7210	Hardware consultancy	Real estate	0.00	0.00	0.00	0.14	0.00	0.00	-3.48
7221	Software publishing	Real estate	0.00	0.00	0.00	0.02	0.00	0.00	-4.06
7229	Other software consultancy and supply	Real estate	0.00	0.00	0.00	0.10	0.00	0.00	-4.47
7230	Data processing	Real estate	0.00	0.00	0.00	0.01	0.01	0.00	-5.86
7240	Database activities and online distribution of electronic content	Real estate	0.00	0.00	0.00	0.52	0.00	0.00	-7.16
7250	Maintenance and repair of office, accounting and computing machinery	Real estate	0.00	0.00	0.00	0.14	0.00	0.01	-4.36
7290	Other computer-related activities	Real estate	0.00	0.00	0.00	0.08	0.00	0.00	-4.59
7310	Research and experimental development on natural sciences and engineering (NSE)	Real estate	0.00	0.00	0.00	0.41	0.00	0.00	-5.87
7411	Legal activities	Real estate	0.00	0.00	0.00	0.30	0.00	0.00	-6.15
7412	Accounting, bookkeeping and auditing activities; tax consultancy	Real estate	0.00	0.00	0.00	0.23	0.00	0.00	-6.09
7413	Market research and public opinion polling	Real estate	0.00	0.00	0.00	0.17	0.00	0.00	-0.48
7414	Business and management consultancy activities	Real estate	0.00	0.00	0.00	1.73	0.00	0.01	-6.79
0742	Architectural, engineering and other technical activities	Real estate	0.00	0.00	0.00	NA	0.00	0.00	NA
7421	Architectural and engineering activities and related technical consultancy	Real estate	0.00	0.00	0.00	0.83	0.03	0.15	-4.49
7422	Technical testing and analysis	Real estate	0.00	0.00	0.00	0.15	0.00	0.00	-5.40
7430	Advertising	Real estate	0.00	0.00	0.00	0.32	0.00	0.00	1.37
7491	Labour recruitment and provision of personnel	Real estate	0.00	0.00	0.00	0.54	0.00	0.00	-4.64
7492	Investigation and security activities	Real estate	0.00	0.00	0.00	3.89	0.00	0.00	-3.34
7493	Building-cleaning and industrial-cleaning activities	Real estate	0.00	0.00	0.00	0.14	0.00	0.00	-4.39
7494	Photographic activities	Real estate	0.00	0.00	0.00	0.05	0.03	0.03	-7.26

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
7495	Packaging activities	Real estate	0.00	0.00	0.00	0.12	0.00	0.00	-2.07
7499	Other business activities n.e.c.	Real estate	0.00	0.00	0.00	0.54	0.03	0.01	-6.58
7511	General (overall) public service activities	Administration	0.00	0.00	0.00	2.90	0.00	0.00	-8.04
7512	Regulation of the activities of agencies that provide health care, education, cultural services	Administration	0.00	0.00	0.00	2.18	0.00	0.00	-7.82
7513	Regulation of and contribution to more efficient operation of business	Administration	0.00	0.00	0.00	0.34	0.00	0.00	-7.16
7514	Supporting service activities for the government as a whole	Administration	0.00	0.00	0.00	0.06	0.00	0.01	-6.69
7521	Foreign affairs	Administration	0.00	0.00	0.00	1.19	0.00	0.00	-6.72
7522	Defence activities	Administration	0.00	0.00	0.00	0.81	0.00	0.00	-4.68
7523	Public order and safety activities	Administration	0.00	0.00	0.00	0.90	0.00	0.00	-7.77
7530	Compulsory social security activities	Administration	0.00	0.00	0.00	0.04	0.00	0.00	-5.87
8010	Primary education	Education	0.00	0.00	0.00	8.05	0.02	0.09	-8.73
8021	General secondary education	Education	0.00	0.00	0.00	2.23	0.00	0.00	-8.50
8022	Technical and vocational secondary education	Education	0.00	0.00	0.00	0.49	0.00	0.00	-7.39
8030	Higher education	Education	0.00	0.00	0.00	1.57	0.00	0.00	-6.50
8090	Other education	Education	0.00	0.00	0.00	0.43	0.01	0.00	-7.00
8511	Hospital activities	Social work	0.00	0.00	0.00	4.80	0.00	0.00	-8.12
8512	Medical and dental practice activities	Social work	0.00	0.00	0.00	0.33	0.03	0.00	-7.38
8519	Other human health activities	Social work	0.00	0.00	0.00	0.57	0.07	0.04	-7.82
8520	Veterinary activities	Social work	0.00	0.00	0.00	0.02	0.00	0.00	-6.52
8531	Social work activities with accommodation	Social work	0.00	0.00	0.00	0.06	0.00	0.00	-6.98
8532	Social work activities without accommodation	Social work	0.00	0.00	0.00	0.03	0.03	0.00	-5.58
9000	Sewage and refuse disposal, sanitation and similar activities	Other	0.00	0.00	0.00	0.92	0.02	0.00	-6.34
0911	Activities of business, employers and professional organizations	Other	0.00	0.00	0.00	NA	0.00	0.00	NA
9111	Activities of business and employers organizations	Other	0.00	0.00	0.00	0.30	0.01	0.00	-5.97
9112	Activities of professional organizations	Other	0.00	0.00	0.00	0.11	0.00	0.00	-6.28
9120	Activities of trade unions	Other	0.00	0.00	0.00	0.11	0.00	0.00	-6.85
9191	Activities of religious organizations	Other	0.00	0.00	0.00	4.02	0.01	0.02	-8.78
9192	Activities of political organizations	Other	0.00	0.00	0.00	0.03	0.00	0.00	-7.20
9211	Motion picture and video production and distribution	Other	0.00	0.00	0.00	0.04	0.01	0.00	-6.36
9212	Motion picture projection	Other	0.00	0.00	0.00	0.00	0.01	0.00	-6.75
9213	Radio and television activities	Other	0.00	0.00	0.00	NA	0.00	0.00	NA
9214	Dramatic arts, music and other arts activities	Other	0.01	0.01	0.00	0.09	0.02	0.05	-6.49
9219	Other entertainment activities n.e.c.	Other	0.00	0.00	0.00	0.07	0.02	0.02	-7.22
9220	News agency activities	Other	0.00	0.00	0.00	0.04	0.00	0.00	-5.53

Table 6: Final dataset *(continued)*

Code	Label (4 digit)	ISIC group	Trade 2003	Trade 2013	Formal 2003	Formal 2014	Household 2005	Household 2013	Log fitness
9232	Museums activities and preservation of historic sites and buildings	Other	0.00	0.00	0.00	0.00	0.00	0.00	-5.20
9233	Botanical and zoological gardens and nature reserves activities	Other	0.00	0.00	0.00	0.02	0.00	0.00	-6.10
9241	Sporting activities	Other	0.00	0.00	0.00	0.10	0.00	0.00	-5.70
9249	Other recreational activities	Other	0.00	0.00	0.00	0.18	0.01	0.02	-7.14
9301	Washing and (dry-)cleaning of textile and fur products	Other	0.00	0.00	0.00	0.15	0.01	0.01	-4.55
9302	Hairdressing and other beauty treatment	Other	0.00	0.00	0.00	0.08	0.56	0.65	-7.57
9303	Funeral and related activities	Other	0.00	0.00	0.00	0.02	0.01	0.01	-6.99
9309	Other service activities n.e.c.	Other	0.00	0.00	0.00	0.01	0.09	0.05	-6.33
9600	Undifferentiated goods-producing activities of private households for own use	Other	0.00	0.00	0.00	NA	0.01	0.00	NA
9500	Unspecified services	Services	0.00	0.00	0.00	0.03	0.00	0.02	-3.36
9501	Travels and tourism	Services	13.96	5.18	0.00	NA	0.00	0.00	-5.06
9502	Transport	Services	4.19	4.23	0.00	NA	0.00	0.00	NA
9503	ICT	Services	2.85	5.27	0.00	NA	0.00	0.00	-2.57
9504	Financial	Services	0.23	0.22	0.00	NA	0.00	0.00	-4.59
9700	Undifferentiated service-producing activities of private households for own use	Services	0.00	0.00	0.00	NA	0.00	0.00	NA
9900	Extraterritorial organizations and bodies	Services	0.00	0.00	0.00	0.17	0.00	0.00	-3.75
9999	Goods and services not elsewhere classified	N/A	1.28	0.94	0.00	NA	0.00	0.00	NA