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INEQUALITY PROJECT



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Working Paper Series

AFRICA'S MANUFACTURING MALAISE

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UNDP's Project on "Inequality in Sub-Saharan Africa"

This is one of the background papers on the UNDP Regional Bureau for Africa's (RBA) comprehensive inequality study in Sub-Saharan Africa. The study intends to contribute to the growing debates on inequality in the continent. Essentially, it aims to understand what factors explain trends in inequality and their positive and negative outcomes and to draw relevant policy lessons that could help the design and formulation of public policies and programs to address inequality in the continent.

Objectives of the study

The specific objectives of the research project are to:

- (i) Provide a comparative analysis of inequality and examine several forms of elasticity of poverty and inequality across African countries and sub-regions;
- (ii) Identify key factors responsible for the inequality and poverty changes observed in Sub-Saharan Africa during the last twenty years, so as to orient future policies towards inclusive growth. An important objective is to identify best practice policies and programs in countries that have experienced favourable progress on inequality trends over the past decade;
- (iii) Examine empirically whether the countries which experienced a transition to democracy and the election of more accountable governments experienced improvements in growth and or inequality, and assess whether trade-offs (if any) between these two are unavoidable or can lead to win-win situations;
- (iv) Analyze the relative importance of various economic, social and political factors in the observed changes in inequality and poverty in different clusters of economies; and
- (v) Identify existing bottlenecks still impeding rapid progress such as dependence on commodity exports, weak industrial policy, reliance on volatile foreign savings, as well as other impediments that could hinder progress in sustaining an inclusive pro-poor growth in the future.

Project Management

The Project is coordinated by Ayodele Odusola, Chief Economist and Head of Strategy and Analysis Team, RBA, under the strategic guidance of Abdoulaye Mar Dieye, RBA Director and Assistant Administrator.

Abstract

The levels of poverty and inequality in Africa are high in relation to the rest of the world. In order to reduce these twin ailments, more and better jobs need to be created. A key source of more and better jobs for developing countries is to be found in the manufacturing sector. Structural transformation involves the shift of productive resources from low productivity primary activities toward high productivity manufacturing activities. Therefore, understanding the constraints that countries face when trying to structurally transform and develop their manufacturing sector is important. In order to analyse the constraints to manufacturing growth, particularly in African countries, we employ the Atlas of Economic Complexity analytical framework developed by Hausmann & Hidalgo (2011). The analysis shows that, in general, African countries have not undergone manufacturing-led growth-inducing structural transformation. However, Africa is not one country, and the analysis demonstrates heterogeneity in the African experience, with some African countries exhibiting growth in their manufacturing sectors. The analysis indicates that the process of structural transformation is a path-dependent one, in which a country's current productive capabilities embodied in its export structure, influence the extent to which it can shift production toward increased manufacturing activity. We argue that, with regard to manufacturing sector growth in Africa, there is no policy 'silver bullet'. Rather, subsequent analysis needs to determine the specific productive capabilities required by manufacturing firms in African countries on a case-by-case basis.

AFRICA'S MANUFACTURING MALAISE

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Views expressed in this paper do not necessarily represent those of UNDP, but those of the authors.

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I. Introduction

Africa is characterised by high levels of poverty and inequality. In 2012, 42.7 percent of Sub-Saharan Africans lived on less than \$1.90 a day (Beegle et al., 2016). Africa's Gini coefficient is 0.56 – the highest of any continent (Beegle et al., 2016). In order to reduce poverty and inequality, the only option available to policymakers – at least in terms of industrial policy – is to create more, and better, remunerated jobs (Söderbom & Teal, 2003). In other words, a country needs to undergo structural transformation – a shift away from the low-productivity agriculture sector and toward higher productivity sectors – in order to achieve an overall growth in income (McMillan et al., 2014). A pre-requisite for creating better paying jobs is economic growth – without access to these jobs, poverty alleviation will be modest (Söderbom & Teal, 2003).

In the African context, the majority of new, high-productivity jobs should ideally be in the manufacturing sector. The manufacturing sector has two distinct advantages over other high-productivity sectors such as the mining or services sectors. Besides tourism (which is outside the scope of this paper), manufacturing is one of the sectors which is both labour-intensive and export-orientated (Söderbom & Teal, 2003). The latter advantage is particularly relevant to Africa, as Africa's domestic markets are small and cannot sustain the high levels of economic growth required to reduce poverty and inequality substantially. Furthermore, there is a strong link between exports and economic growth (Söderbom & Teal, 2003).

However, recent experience in Africa suggests that, despite strong economic growth over the past decade, the manufacturing sector has remained subdued. Two recent studies by Rodrik (2014) and McMillan & Harttgen (2014) investigate the drivers behind the 'African growth miracle'. In both studies, there is evidence of growth in manufacturing, measured as growth in manufacturing's share of total employment, but the authors point to this growth as being relatively minor. McMillan & Harttgen (2014) find evidence of structural transformation, pointing to declining employment shares in agriculture, accompanied by rising shares of employment in manufacturing and services. However, they note that the expansion of manufacturing has not been significant, whereas the growth in services has been sizeable. Essentially, the post-2000 period of growth in Africa has witnessed the declining importance of agriculture, a significant increase in the importance of services, and somewhat stagnant performance in manufacturing.

Given that structural transformation is vital to sustained long-run economic growth and development, the evidence suggesting limited structural transformation remains a key cause for concern for Africa's development trajectory. The sustainability of Africa's long-run economic performance is important because it impacts on the continent's ability to achieve key developmental objectives, such as poverty reduction, a more equitable distribution of income, enhanced human capital accumulation, and improved infrastructure.

With the marginal performance of manufacturing in Africa in mind, we seek to explore what factors may be constraining the growth of manufacturing in Africa. If the growth of the manufacturing sector in Africa is key to growth-enhancing structural transformation, then understanding the factors that are constraining this type of growth is of prime importance.

We do this by employing the Atlas of Economic Complexity analytical framework developed by Hausmann & Hidalgo (2011). Firstly, we use this framework to examine evidence for structural transformation in Africa and we tailor the framework to provide insight into manufacturing performance across African countries. Secondly, we incorporate the economic complexity and opportunity value indices derived from the Atlas of Economic Complexity analytical framework into regression estimates that examine the factors constraining manufacturing performance.

This paper is structured as follows: Firstly, we refer to the literature in order to critically examine the role of manufacturing in structural transformation and economic development. Secondly, we examine the evidence for structural transformation in Africa. Thirdly, we outline our methodology and data employed in our econometric analysis. This is followed by a discussion on the regression results. Finally, we conclude by providing a number of policy implications derived from the analysis.

II. Manufacturing in Growth and Development: A Review of the Literature

In this section, we examine the economic literature which looks at the role that manufacturing plays in economic growth and development. Firstly, we look at the process of structural transformation, how it is seen as an engine of economic growth and development, and how this relates to manufacturing growth. With regard to the process of structural transformation, we look at two strands of this literature. Firstly, we review those studies that set out to understand the relationship between structural transformation and overall productivity growth in an economy. Secondly, we survey the literature focused on how structural transformation may be associated with a shift from traditional to modern economic activities.

2.1 Structural Transformation and Economic Development

A key aspect behind economic growth and the sustained development of a country's economy is the notion of an evolving economy. It involves an economy undergoing a structural shift in production away from traditional low-productivity activities toward complex high-productivity activities. This process of structural change within an economy is described by McMillan et al. (2014) as the engine of sustained economic growth.

Economic growth models are able to explain this process of structural change to varying degrees. The neo-classical nature of the Solow-Swan growth model means that it unfortunately assumes that all economic activities are similar enough to be captured in a single sector (Rodrik, 2013). Therefore, this model is a poor tool in terms of understanding how economies evolve. On the other hand, the Romer (1990) and Lucas (1988) models provide a parsimonious explanation for structural change: as the stock of human capital increases (i.e. the average level of education increases), people move away from sectors which require a low amount of human capital, such as agriculture, and into sectors where a greater amount of human capital is required (e.g. manufacturing or services) as people are better remunerated in these areas (Gillman, 2011).

Structural transformation is defined as "the reallocation of economic activity away from the least productive sectors of the economy to more productive ones. It is the fundamental driver of economic growth" (African Development Bank, 2013). Structural transformation comprises two elements. The first is the rise of new productive activities, which drives the economy forward. The second is raising overall productivity through the movement of resources from traditional activities to new activities. In the sections which follow, we examine some of the key insights obtained from the literature, with regard to these two elements of structural transformation.

2.1.1 Structural Transformation and Productivity Growth

Structural transformation is arguably fundamental for countries in order to alleviate poverty, by diversifying away from agriculture and other traditional products. This process occurs through the movement of labour and other resources. As labour and other resources move from agriculture and other traditional activities toward more complex modern economic activities, overall productivity and income increases. However, the key to success is the speed at which transformation occurs (McMillan et al. 2014). This depends on the country's level of development.

The African Economic Outlook 2013 found that poor countries have the largest differences in productivity between sectors (African Development Bank, 2013). The poorer the country, the wider the gap between the least and most productive sectors. In contrast, as a country grows richer, through an increase in productivity gains in sectors that produce the largest amount of productivity, the productivity gap between the least and most productive sectors decreases and intra-sector productivity differences take precedence.

Increased labour productivity can be achieved in two ways: the first is through growth in economic sectors that occurs through capital accumulation, technological change, or reduction of misallocation among plants. The second occurs through the movement of labour from low-productivity sectors to high-productivity sectors. Such a tendency leads to an increase in labour productivity in the economy.

However, this has not been the case for Africa, where labour has moved in the opposite direction. As such, structural change in Africa has had a negative contribution to overall growth, which is in contrast to the structural transformation success story in Asia (McMillan et al., 2014).

Africa's lack of successful structural transformation is the result of poor performance on the part of the primary sector and not the large share of the sector. Poor performance has been the result of lack of agricultural upgrading. Globalisation has also not been as beneficial to Africa as it has been to Asia. Globalisation promotes specialisation by comparative advantage and, in the case of Africa, this is most prevalent in natural resources and primary products. African countries are thereby forced into traditional specialisation, as opposed to expanding modern manufacturing activities. Furthermore, some aspects of the traditional specialisation, such as minerals, are capital-intensive and require high levels of labour productivity which limits the creation of sustainable employment (McMillan et al. 2014).

Harrison et al. (2014) state that in the 1960s, on aggregate, the South Asian and African economies experienced similar rates of economic growth. However, between 1970 and 2000, average GDP per capita growth in African countries decreased to 0.5 percent per annum. Although the continent is now experiencing a "growth miracle", the sustainability and inequitable distribution of the gains of growth remain of concern. It is therefore important for growth to occur in productivity-enhancing sectors. This scenario remains possibly the major economic development challenge for Africa.

2.1.2 Structural Transformation and Shifts in Production

A key aspect in the process of structural transformation is the shift away from activities in agriculture and other traditional sectors toward activities in more complex sectors, in particular, manufacturing. Implicit in this process of structural transformation is the diversification of the economy's productive activities. Such a process is evidenced in a study by Imbs & Wacziarg (2003) who investigated the relationship between economic development, measured using GDP per capita, and the evolution of sectoral diversification. Using production and employment data at a sectoral level, they investigated whether there is a path of diversification along which countries shift as they develop. Their analysis revealed a 'u-shaped' development path where, as a country shifts from lower levels of economic development, there is increased sectoral diversification (or declining concentration). This pattern of diversification continues until, at a relatively high level of economic development, a turning point is reached, with concomitant increased levels of development, and with re-specialisation (or increasing concentration) of the economies' productive structure.

Subsequent studies have taken the Imbs & Wacziarg (2003) analysis further by using highly disaggregated product level export data to examine this u-shaped pattern in greater detail. (see Cadot et al., 2011; Klinger & Lederman, 2011). Cadot et al. (2011) show that increased levels of diversification as a country develops is driven by the entry into new product markets. Klinger & Lederman (2011) argue that the entry into new product markets is linked to technological convergence between rich and poor countries. Low- to middle-income countries can adopt technologies developed by advanced countries with relative ease, termed 'within frontier export discoveries', and thus diversify the range of products that they export. It is expected that this process of 'discovery' driven diversification involves increased production of manufactured products with increasing levels of complexity as a country develops and graduates to higher levels of economic development. As such, the process of export diversification is closely linked to the process of structural transformation.

2.1.3 Structural Transformation and 'Picking Winners'

A number of studies acknowledge the developmental importance of the diversification of an economy's productive structure, evidenced by a diversifying export portfolio, and the resultant associated structural change. However, such studies argue that the type of products that an economy diversifies towards is of key importance.

For instance, and with particular relevance to resource-rich Africa, there are a number of studies in existence that examine the natural resource-curse hypothesis.² The resource-curse hypothesis states that, on average, resource-rich countries tend to grow more slowly than resource-poor countries. The most influential of these studies is that by Sachs & Warner (1995; 2001) who find that there is a negative and statistically significant coefficient for the variable capturing resource dependence, when controlling for other growth variables such as geography and institutions.

Proponents of the 'resource-curse effect' argue that a number of channels exist through which resources adversely impact on economic development. Firstly, the terms of trade argument posed by Prebisch (1959), argues that the price of commodities relative to manufacturing is said to follow a downward trajectory over time, and consequently those countries specialising in resource-intensive activities will experience declining terms of trade over time. Secondly, proponents of the 'Dutch disease' argument, such as Sachs & Warner (1995), argue that, in the wake of a commodity boom, the growth of the resource sector 'crowds-out' manufacturing activity. Thirdly, a political economy type argument contends that resource abundant countries are less likely to develop sound institutions because of elites competing over resources rents. It is argued that those countries characterised by weak institutions have a higher likelihood of armed conflict. Finally, commodity prices tend to exhibit significant levels of volatility. This phenomenon, coupled with export concentration in natural resource based exports, results in broader macroeconomic volatility. In essence, studies advancing the resource-curse hypothesis suggest that resource-rich countries with resource-intensive production patterns underperform relative to resource-poor countries that tend to be more manufacturing- orientated.

However, the strength of the analysis posed by Sachs & Warner (1995) needs to be considered in light of a number of studies contesting the resource-curse hypothesis. These studies are driven by the notion, and thus providing hope in the case of African countries, that it is counter-intuitive to consider natural resources as being a constraint on development as opposed to a blessing. Some studies argue for a 'conditional resource-curse'. For instance, Mehlum et al. (2006) argue that the quality of a country's institutions influence whether it is able to successfully exploit its abundant natural resources. They find that resource-rich countries with weak institutions are associated with low growth, whereas resource-rich countries with strong institutions are associated with high growth. Similarly, Bravo-Ortega & de Gregorio, (2007) argue that the resource-curse is dependent upon the level of human capital in a country. In this instance, low levels of human capital and resource abundance are associated with low growth, whereas high levels of human capital and resource abundance are associated with higher levels of economic growth.

Perhaps most damagingly to the resource-curse hypothesis is recent work by Lederman & Maloney (2007; 2009) who find little evidence for the curse. Rather it is argued that the resource-curse is a 'curse of concentration', and it is countries that are overly-dependent upon the exports of just a few natural resource-based products that are associated with the negative growth effects. Furthermore, a case study analysis of Scandinavian countries by Blomstrom & Kokko (2007) argues that the current diverse high-tech manufacturing industries in these countries were developed upon the foundation of knowledge- and technology-intensive natural resource industries. For example, the high-tech telecom company, Nokia, emerged from a forestry company.

In summary, the evolution of this literature seems to be pointing to the notion that natural resource abundance does not, in and of itself, restrict an economy to low levels of economic development as assumed by the resource-curse hypothesis.

For instance, see Auty (1994; 2000; 2001) and Sachs & Warner (1995; 2001).

This is a promising outcome from an African perspective. Rather, the developmental benefits of resource abundance are tied closely to whether a country is able to develop resource-based industries in a knowledge- and technology-intensive manner so as to facilitate the future emergence of related, associative manufacturing industries.

As opposed to advising what industries not to 'pick', another strand in this literature focuses on what industries/products countries need to shift toward in order to facilitate the process of structural change and economic development. Hausmann et al. (2007) argue that countries become what they produce, and countries that produce products that are associated with high levels of productivity, or 'rich country' products, experience higher levels of economic growth and development. Structural change involving a shift to 'rich country' products is likely to reap future economic benefits. These products tend to be sophisticated manufacturing products, which suggests that a structural shift toward manufacturing is a key aspect of the development process.

Hausmann & Klinger (2006) expound on the notion that structural transformation is a path-dependent process. Using the product space mapping developed by Hidalgo et al. (2007) they argue that a country's ability to undergo structural transformation and thus diversify toward more advanced manufacturing products, is influenced by what a country is currently producing. In other words, the ability of a country to change its productive structure is influenced by its current productive structure. The rationale behind this idea is that the production of specific products requires various combinations of imperfectly substitutable assets and capabilities. The probability of shifting production toward a new product depends upon how proximate the assets and capabilities embodied in the existing production structure are to those required by the new product. The product space mapping developed by Hidalgo et al. (2007) is a visual representation of the proximate distances between various products that countries trade.

Hidalgo et al. (2007) show that poorer countries mainly produce products on the periphery of the product space mapping while richer countries primarily produce products at the core of the product space. From a structural transformation perspective, two points emerge: Firstly, products that comprise the core of the product space tend to be manufactured products while products that comprise the periphery tend to be resource-based products. Secondly, the distance between products within the core of the product space is less than the distance between core and peripheral products. As such, shifting production toward manufactured products is easier if a country already has a manufacturing sector. Conversely, shifting production toward manufactured products for countries that mainly produce peripheral products is much harder, since the assets and capabilities embodied in its current productive structure are not aligned with those needed in manufacturing activities. Therefore, the Hidalgo et al. (2007) thesis provides an insightful framework for thinking about the difficulties that African countries face in transforming their productive structures from primary to secondary sector production, from mining- and agriculture-based production towards manufacturing.

More recent work by Hidalgo et al. (2009) and Hausmann & Hidalgo (2011) complement the product space framework by providing measures of product complexity and country complexity. These studies advance a framework where the complexity of a country is related to the complexity of the products that it produces, given that behind the production of each product is a set of productive capabilities that enable the production of a product. Furthermore, such studies measure the complexity of products that countries produce and export using the Method of Reflections, which uses information on the diversity of a country's export portfolio and information on the ubiquity of the products that countries export. The rationale behind this method is that a product that is scarce and is typically exported by countries with diverse export portfolios, is complex because countries that are more diverse have more capabilities and products that are scarce require more specialised capabilities. As such, the more complex the products a country exports the rule of thumb is that the country is more complex. Hausmann & Hidalgo (2011) shows that their measures of economic complexity, derived from their measures of product complexity, can explain differences in cross-country income levels as well as predict future economic growth patterns.

From the African manufacturing perspective, the product space and product complexity framework have a number of implications. Firstly, if African countries primarily manufacture products in the periphery of the product space, which is expected, then it is likely that their economies have less productive capabilities and are consequently less complex.

Secondly, if African countries feature relatively low in terms of economic complexity then this is likely to reflect in their economic performance. Thirdly, if the export portfolios of African countries are more peripheral, and hence they have limited capabilities, then the ease at which they can transform their economies and shift toward more complex core products, typically manufactured commodities, is limited.

In the next section, we turn our attention to examining the evidence for structural transformation in African countries, and the extent to which manufacturing has driven structural change. We do this by using the product space analytical framework developed by Hausman & Klinger (2006) and Hidalgo et al. (2007), and the related economic complexity framework developed by and Hausmann et al. (2011).

III. Evidence of Structural Transformation in Africa

The manner in which countries develop, and hence undergo the process of structural transformation, can be examined along two dimensions. Firstly, as in McMillan et al. (2014), one can examine the shifts in labour and other resources away from low-productivity activities toward high-productivity activities. This is achieved by examining sector shares in terms of employment and value-added over time. Secondly, as in Hausmann & Klinger (2006), one can examine how shifts in resources from agriculture and other traditional activities, toward more complex modern activities, raise aggregate productivity and income. In this section, we analyse both these dimensions.

3.1 Structural transformation: From Low- to High-Productivity Activities

According to McMillan et al. (2014), one way of thinking about structural transformation is to consider it as a process of addressing allocative efficiencies. Allocative inefficiencies are evident in economies characterised by large cross-sector productivity gaps, as is typically the case within developing countries. The movement of labour, and other resources, away from low-productivity activities, typically agriculture, toward high-productivity activities in manufacturing, results in a rise in aggregate productivity across the economy.

Following McMillan et al. (2014) and using the GGDD 10-sector Database (Timmer et al., 2014), Figure 1 depicts this shift of employment across sectors varying in terms of productivity. This is done by plotting the productivity across ten sectors in 2010 against the change in employment within these sectors, over the period 1975 to 2010, for an African regional aggregate. In essence, the graph is showing whether shifts in the structure of the economy, in terms of shifts in employment across sectors, have been toward productive or unproductive activities. A positively sloped fitted line is indicative of productivity enhancing, and hence growth inducing, structural change. Conversely, a negatively sloped fitted line is indicative of productivity reducing, and hence growth reducing, structural change.

Looking at Figure 1, there is evidence of growth inducing structural transformation in Africa over the period 1975 to 2010.³ While remaining the largest employer, the low productivity agriculture sector has incurred the highest employment losses over the 35-year period. The high-productivity manufacturing sector has remained stagnant with regard to employment growth. The biggest beneficiaries of Africa's growth have evidently been services, with government, transport, business, and trade services increasing their share of employment over the period. Unfortunately, the most productive sectors – mining and utilities – have not seen employment growth at all. This is indicative of the high level of capital intensity associated with these industries.

It must be noted that the estimated regression line, measuring the relationship between productivity and changes in employment share by sector, is not statistically significant.

Figure 1: Sectoral Productivity and Employment Change in Africa, 1975 - 2010



Source: Own calculations using Groningen Growth and Development Centre 10-sector database (Timmer et al., 2014)

Notes: 1. African countries included: Botswana, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Nigeria, Senegal, South Africa, Tanzania and Zambia. 2. AGR = Agriculture; MIN = Mining; MAN = Manufacturing; UTI = Utilities; CONT = Construction; WRT = Trade Services; TRS = Transport Services; BUS = Business Services; GOS = Government Services; PES = Personal Services.

3.2 Structural Transformation: Economic Complexity and The Product Space

The analysis in the previous sub-section provides an overview of whether there has been a shift from low-productivity activities toward high-productivity activities, but provides little insight into the process behind this shift. In this sub-section we use the analytical framework and empirical tools from the Atlas of Economic Complexity to, firstly, examine the extent to which African countries have undergone structural transformation, and secondly, to draw on the rationale for this framework in order to understand the process of structural transformation. The shift to manufacturing activities is a key element of structural transformation, and thus a better understanding of this process may offer insights into the drivers of African manufacturing performance.

Hausmann et al. (2011) argue that the path-dependent process of structural transformation is essentially a process of acquiring productive capabilities, and hence increasing the complexity of a country's economy. Hidalgo et al. (2009) describe these productive capabilities as non-tradable country characteristics such as institutions, infrastructure, and the business environment. The notion of a country acquiring productive capabilities is encapsulated in the measure of economic complexity developed by Hidalgo et al. (2009), and further discussed by Hausmann et al. (2011) in the Atlas of Economic Complexity. The rationale behind this idea is described by Hausmann et al. (2011) using the game of scrabble as an analogy (see Box 1). In applying this analytical framework, two important ideas emerge: firstly, a country's productive structure is determined by its productive capabilities, and hence its economic complexity; secondly, the process of structural transformation involves the acquisition of productive capabilities, and this process is path-dependent. Before explaining how this process of structural transformation relates to the African manufacturing context, we start by exploring the notion of *economic complexity*.

3.2.1 The Notion of Economic complexity

The complexity of an economy, and the associated measure of economic complexity developed by Hidalgo et al. (2009), refers to the multiplicity of productive capabilities within an economy. The notion and measure of economic complexity is built on Adam Smith's idea that as economies develop, there is increased specialisation and a growing division of labour within an economy. As such, there are a multitude of individual activities which constitute a network of productive activities that combine, resulting in products of increasing complexity. Armed with this notion and the analytical tools of network analysis, Hidalgo et al. (2009) exploit the bipartite network structure of trade, in which countries are connected to the products that they produce, to quantify the complexity of a country's economy.

A country's measure of economic complexity is based on two components (see Box 1): Firstly, the number of products that it exports, hence the diversity of its export structure, and secondly, the ubiquity of the products that it exports. The combination of these two measures, and the use of an iterative calculation procedure applied in network analysis, the Method of Reflections, generate quantitative measures of complexity. These two measures of complexity are: the Economic Complexity Index (ECI), and the Product Complexity Index (PCI). The ECI is a measure of the productive capabilities specific to each country, and the PCI is a measure of the productive capabilities required to produce each product.⁵

Box 1: Rationale behind the Hausmann et al. (2011) notion of Economic Complexity and Path Dependent Structural Transformation

The game of scrabble involves players using lettered tiles to build words. The analogy put forward by Hausmann et al. (2011) states that each player is a country, that each word a player builds is a product, and that each letter from the alphabet represents a capability (or productive knowledge) needed in order to manufacture a product. They put forth an adapted version of the game where each player has many copies of the letters that they have.

The measure of economic complexity developed by Hidalgo et al. (2009) corresponds to estimating what fraction of the alphabet a player possesses (a country's capabilities), using information on how many words a player can make (the number of products a country can manufacture), and how many other players can make those same words (how many other countries can manufacture those products).

If a player has a lot of letters (capabilities) then she/he is able to make more words (products). Hence the diversity of the words (products) that a player (country) can make depends on the number of letters (capabilities) that she/he has. The number of players (countries) that are able to make a word (product) provides information on the variety of letters (capabilities) needed to make a word (product). Long words tend to be less ubiquitous since only a few players have the requisite letters needed to put it together. Shorter words tend to be more ubiquitous (or common) since more players are likely to have the requisite letters needed to put it together. Hence, ubiquitous products are more likely to require fewer capabilities, while less common products are more likely to require a large variety of capabilities.

Source: Hausmann et al. (2011) and Hausmann et al. (2014)

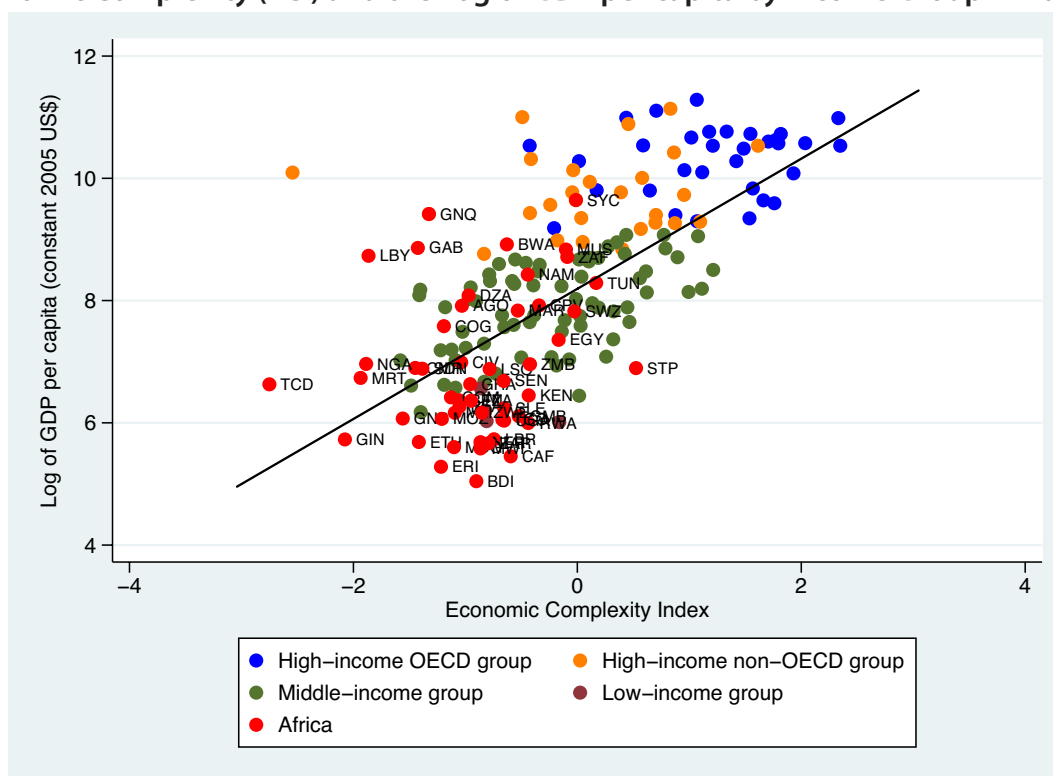
⁵ These measures can be accessed from The Economic Complexity Observatory (Simoes & Hidalgo, 2011) website. Furthermore, an explanation on the derivation of these measures is available on the above-mentioned website and more formally in Hidalgo et al. (2009) and Hausmann & Hidalgo (2011).

3.2.2 Economic complexity and Manufacturing in Africa

Economic complexity, as measured in the ECI, is closely linked to a country's level of development and its future economic growth (Hausmann et al., 2011). In light of this fact, it is interesting to consider the ranking of African countries relative to other countries – this is depicted in Figure 2. Figure 2 shows the relationship between the log of GDP per capita and economic complexity across a sample of low-, middle- and high-income countries. As in Hausmann et al. (2011), a positive relationship between a country's productive capabilities and its level of economic development is evident, further emphasised by the grouping of countries according to levels of economic development.

However, of more interest is the positioning of African countries – identified by the red markers. The clustering of red markers in the south-west corner of Figure 2 indicate that African economies are associated with lower levels of economic complexity and consequently lower levels of economic development. It is worth noting that the African context is heterogeneous. Although there is a cluster of African countries associated with low levels of economic complexity, there are also a few African countries spread toward the north-east of Figure 2, which are associated with higher levels of economic complexity and economic development.

Figure 2: Economic Complexity (ECI) and the Log of GDP per capita by Income Group in 2013



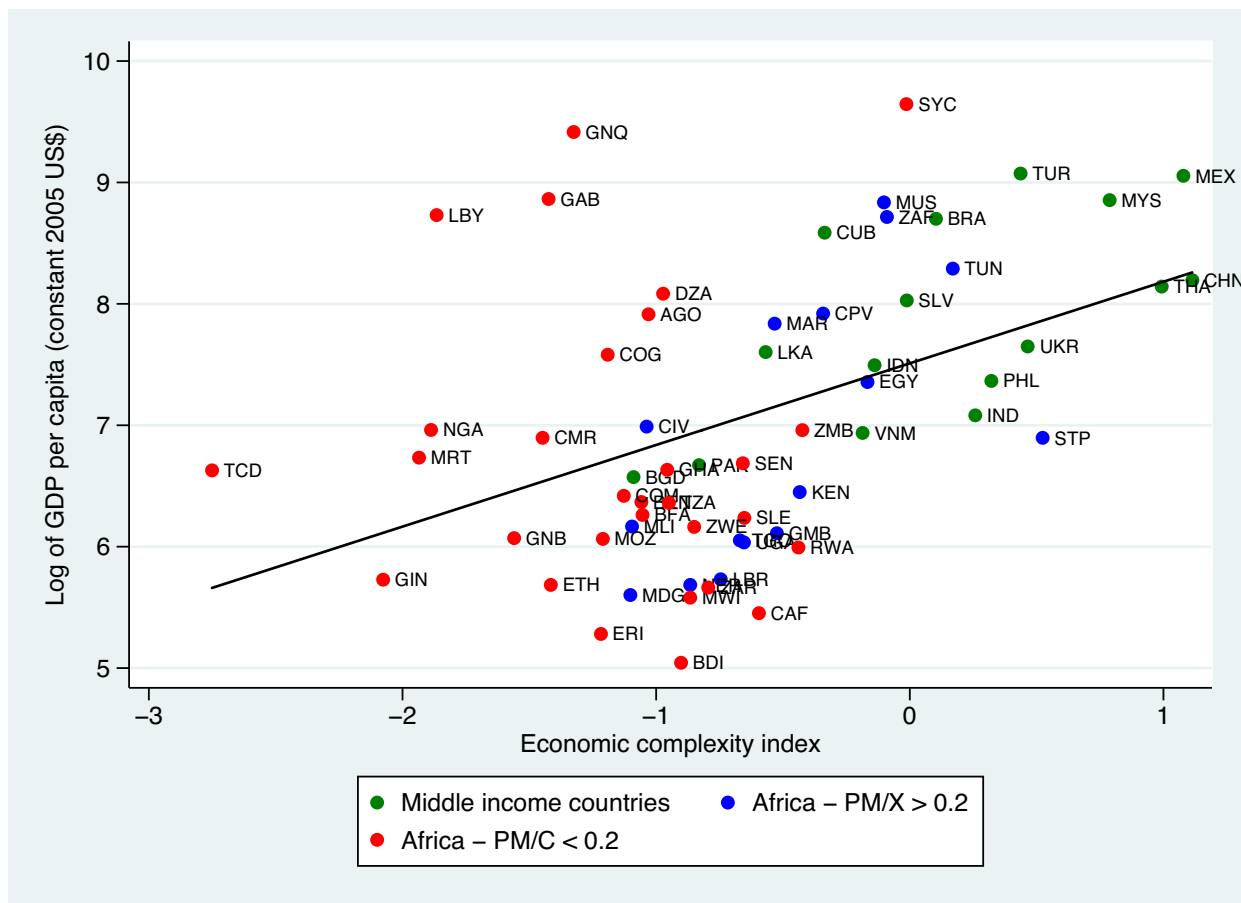
Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011)

In order to unpack the African context further, especially in relation to manufacturing, we adapt Figure 2 by focusing on a sample of other middle-income countries, and two groups of African countries. The African countries are grouped according to whether or not their share of pure manufacturing exports to total exports is greater than 20 percent as of 2013. This is depicted in Figure 3. The rationale behind grouping African countries according to whether their share of pure manufacturing exports to total exports exceeds 20 percent is done in order to try and distinguish between African countries that have a relatively substantial manufacturing sector and those that do not.⁶

⁶ Pure manufacturing exports refer to manufactured products that do not incorporate a significant share of natural resource inputs as a part of their production.

Looking at Figure 3, a number of points are worth mentioning: Firstly, African countries that are ‘substantial exporters’ of manufactured products (blue markers), such as relatively more developed Mauritius, South Africa, Tunisia, Morocco and Egypt, tend to have higher levels of economic complexity. Secondly, there is a group of African countries that are ‘substantial exporters’ of manufactured products, but have relatively lower levels of economic development (blue markers) – Cote d’Ivoire, Kenya, Uganda, Togo, Malawi and Madagascar. However, given their level of economic complexity, and the notion that higher levels of economic complexity is a good predictor of future economic growth and development, these countries may well come to constitute emerging manufacturing hubs within the region. Thirdly, in relation to top-performing emerging market countries such as China, Mexico, Malaysia, Turkey, Thailand, Brazil and India, Africa’s top manufacturing exporters have lower levels of economic complexity and hence lower levels of productive capabilities. Fourthly, a number of African countries have relatively high levels of economic development, measured in real GDP per capita, but low levels of economic complexity – Libya, Gabon, Equatorial-Guinea. The relatively higher levels of GDP per capita in these economies are most likely driven by resource windfalls (i.e. oil exports) that are associated with relatively low levels of economic complexity.

Figure 3: Economic Complexity (ECI) and the Log of GDP per capita by Middle Income Country and African Country Groups in 2013



Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011)

Notes: 1. The middle income country groups, depicted by the green markers refers to a sample of non-African middle-income countries. 2. The blue markers refer to African countries whose pure manufacturing exports as a share of total exports exceed 20 percent. 3. The red markers refer to African countries whose pure manufacturing exports as a share of total exports are less than 20 percent.

Nevertheless, despite some heterogeneity, the relatively low levels of economic complexity across African countries imply low levels of productive capabilities, and this has implications on the ability of these economies to acquire more productive capabilities and shift to more complex manufacturing activities. This is explored using another analytical tool contained within the Atlas of Economic Complexity – the product space analysis developed by Hausmann & Klinger (2006) and Hidalgo et al. (2007).

3.2.3 Considering the Product Space

Standard Neo-Classical trade theory suggests that a country's productive structure, or pattern of specialisation, is determined by the underlying characteristics of the country, such as factor endowments and technology. Changes to the productive structure are driven by accumulation of these underlying characteristics. For example, the Rybczynski theorem, derived from the Heckscher-Ohlin model, states that the accumulation of a factor endowment such as capital results in a shift in production toward more capital-intensive products. These models have little to say about whether shifts in a country's productive structure are influenced by its current productive structure. However, recent studies by Hausmann & Klinger (2006) and Hidalgo et al. (2007) argue, using the *product space* analytical framework, that a country's current productive structure affects its future productive structure, and hence the process of structural transformation is path dependent.

The rationale behind the product space framework is explained by Hausmann et al. (2011) using the 'chicken and egg' problem. The accumulation of productive capabilities, which is associated with higher levels of economic development, is simultaneously aligned to the development of new industries that use this knowledge. If there is no demand for the new industry, then there is no incentive to accumulate the requisite productive capabilities. However, without the requisite productive capabilities, it is impossible to develop the new industry. Therefore, as Hausmann et al. (2011) argue, countries tend to move from products that they are currently producing to 'nearby' products. 'Nearby' products refer to products in which the required productive capabilities is similar to the productive capabilities embodied in the country's current productive structure. In other words, it is easier to shift from shirts to jackets, than from shirts to catalytic converters. This suggests, crucially and of particular relevance to the African context, that the process of structural transformation is path-dependent.

Hausmann & Klinger (2006) investigated the hypothesis that countries diversify by moving into products that require similar productive capabilities to products that they already produce, and formulated the product space framework. The product space is a graphical depiction of the distance between products, where the distance is a measure of the difference in productive capabilities required in order to produce them. Products that are closer to one another require similar productive capabilities, and thus it is easier for countries to move to nearby products. The distances and connections between products generate the structure of the product space. Further detail on analysing a product space graph is provided in Box 2.

The product space framework suggests that the process of accumulating productive capabilities and shifting to new products is not haphazard but rather path-dependent. In other words, a country's current productive structure influences its future productive structure, and hence the process of structural transformation does not take place within a vacuum.

An important aspect of the product space is the presence of a core and periphery. The core is comprised of relatively more proximate and connected products, typically manufactured products, while the periphery is comprised of relatively less proximate and connected products, typically primary products. This scenario has implications for the process of structural transformation and the ability to shift into more complex

manufactured products. If a country's productive structure is represented by a number of products within the core of the product space, then its ability to diversify into new products is made easier by the fact that there are many nearby products which require productive capabilities similar to those that it already possesses. Conversely, if a country's productive structure is more peripheral, then its ability to diversify into products in the core of the product space, typically manufacturing products, is limited because its productive capabilities are 'far' from those that it requires in order to diversify.

Box 2: Decoding the Product Space Framework

In order to create the product space, Hidalgo et al. (2007) use product-level trade data at the 4-digit level of the Harmonised System (HS) (1241 product groups) and the Standard Industrial Trade Classification (SITC) (1033 product groups). Each node represents a product and the size of the node is determined by its share of each respective country's total export trade. Nodes are linked based on the probability that the two products are co-exported by countries, with higher probabilities depicted by thicker and darker lines. A country is deemed to export a product if the Revealed Comparative Advantage measure for that country-product combination is greater than or equal to unity (hence it is a significant export within a country's export portfolio).

The links between products define the structure of the product space and hence the connectedness and distance between products. Products that are close together have similar productive knowledge and capability requirements, which implies that countries find it relatively easier to jump to nearby products. Conversely, it is much harder to jump to products that are more distant from a country's current productive structure. The structure of the product space implies that the process of accumulating productive knowledge and shifting to new products is not haphazard but rather path-dependent. Therefore, products that a country currently manufactures, influences the products that it is able to manufacture in the future.

The colour of each node represents product communities. These are groups of products that are connected to one another more strongly, because they tend to be co-exported more frequently than products existing outside of their community. This implies that products within a community require similar sets of productive capabilities. The HS classification has the following product communities: Animal and Animal Products, Vegetable Products, Foodstuffs, Minerals, Chemicals and Allied Industries, Plastic/Rubber, Raw Hides, Skins, Leather & Furs, Textiles, Footwear/Headgear, Wood & Wood Products, Stone/Glass, Metals, Machinery/Electrical, Transportation, Miscellaneous, and Services.

Source: Hausmann et al. (2011) and Hausmann et al. (2014)

3.2.4 The Product Space and Manufacturing in Africa

The product spaces for a sample of African countries, which vary in terms of manufacturing performance, economic size, and regional make-up, are presented in Figure 4 to Figure 10. A product space for each country for the periods 1995 and 2013 is presented.

By looking at the occupied nodes for each of these countries, it is evident that the productive structure of African countries tends to be, on aggregate, peripheral, and that this has not changed much over the period 1995 to 2013. As such, two points are worth mentioning.

Firstly, these peripheral products are predominantly primary products (e.g. the large nodes for Ghana are Gold, Cocoa Beans, and Petroleum Oil), and this provides insight into the overall levels of economic complexity, and hence productive capabilities inherent in African economies. Primary products are associated with lower levels of product complexity (the PCI measures for primary products tend to be lower) and this translates into lower levels of economic complexity – as is evident in Figure 2. Relatedly, the peripheral character of their

productive structures is matched by the paucity of manufactured products (i.e. very few occupied nodes in the core of the product space).

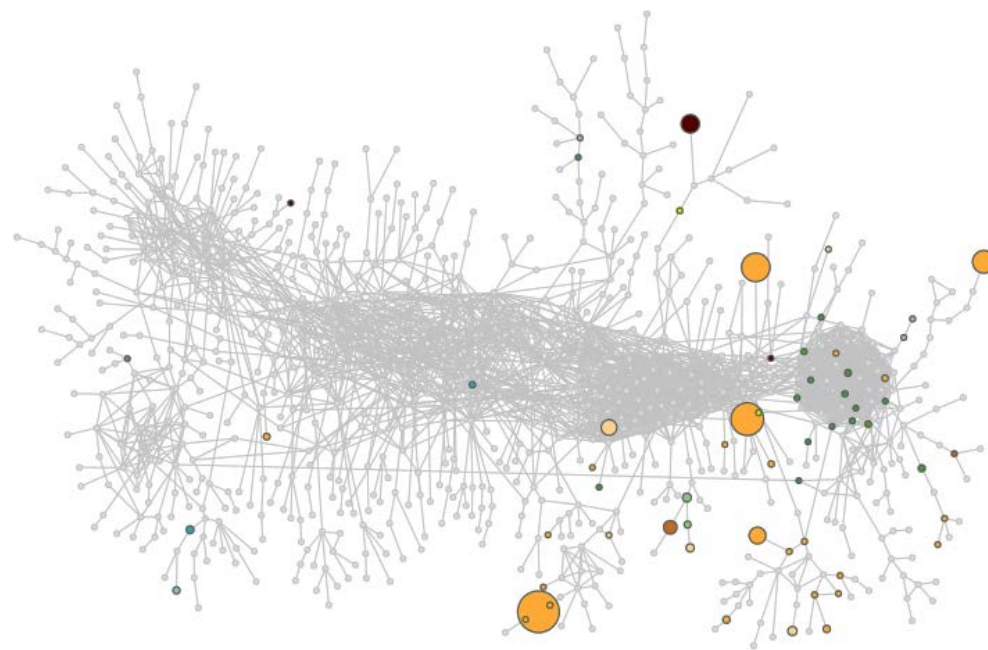
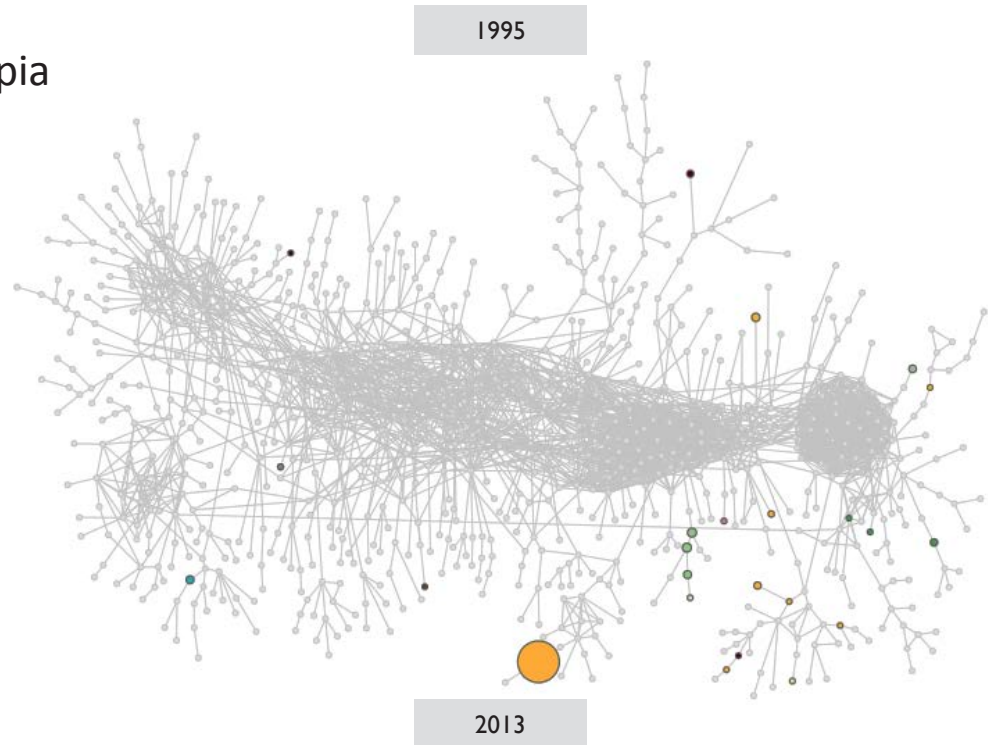
Secondly, the peripheral nature of the productive structures of these African economies has implications for structural transformation. Primary products found in the periphery of the product space are relatively distant from manufactured products found in the core of the product space. Intuitively, this means that the productive capabilities embodied in the production of relatively less complex primary products is distant from the productive capabilities required in order to produce manufactured products in the core of the product space. As such, the peripheral nature of the productive structures of these African economies suggests that diversifying into new products, particularly relatively distant manufactured products, is difficult. As such, the process of structural transformation, in terms of shifts into manufacturing, is hindered by the existing productive capabilities of these economies. This seems to play out when comparing the products spaces across time for each of these countries. In general, over the 19-year period between 1995 and 2013, there has been relatively little change in the productive structures of these economies.

















Although one could argue that the 'average African' productive structure is peripheral, there is evidence of heterogeneity within this grouping in terms of countries across the continent. For instance, the product spaces for Ethiopia, Uganda, and Mauritius, depicted in Figure 4, Figure 6, and Figure 10, respectively, are examples of manufacturing success stories. In each of these cases, it is evident that the number of occupied nodes within the core of the product space has increased.

Uganda provides an exemplar of how the existing productive structure influences the future productive structure. Uganda's product space in 1995 shows a handful of products in the core of the product space. In 2013, it is evident that the Ugandan economy diversified, with shifts to other nearby manufactured products in the core of the product space. This suggests that the productive capabilities associated with the core manufactured products in 1995 was close enough to the productive capabilities required by nearby manufactured products, and consequently Uganda was able to diversify into other manufactured products in time.

Figure 4: Product Space Ethiopia, 1995 and 2013

Ethiopia

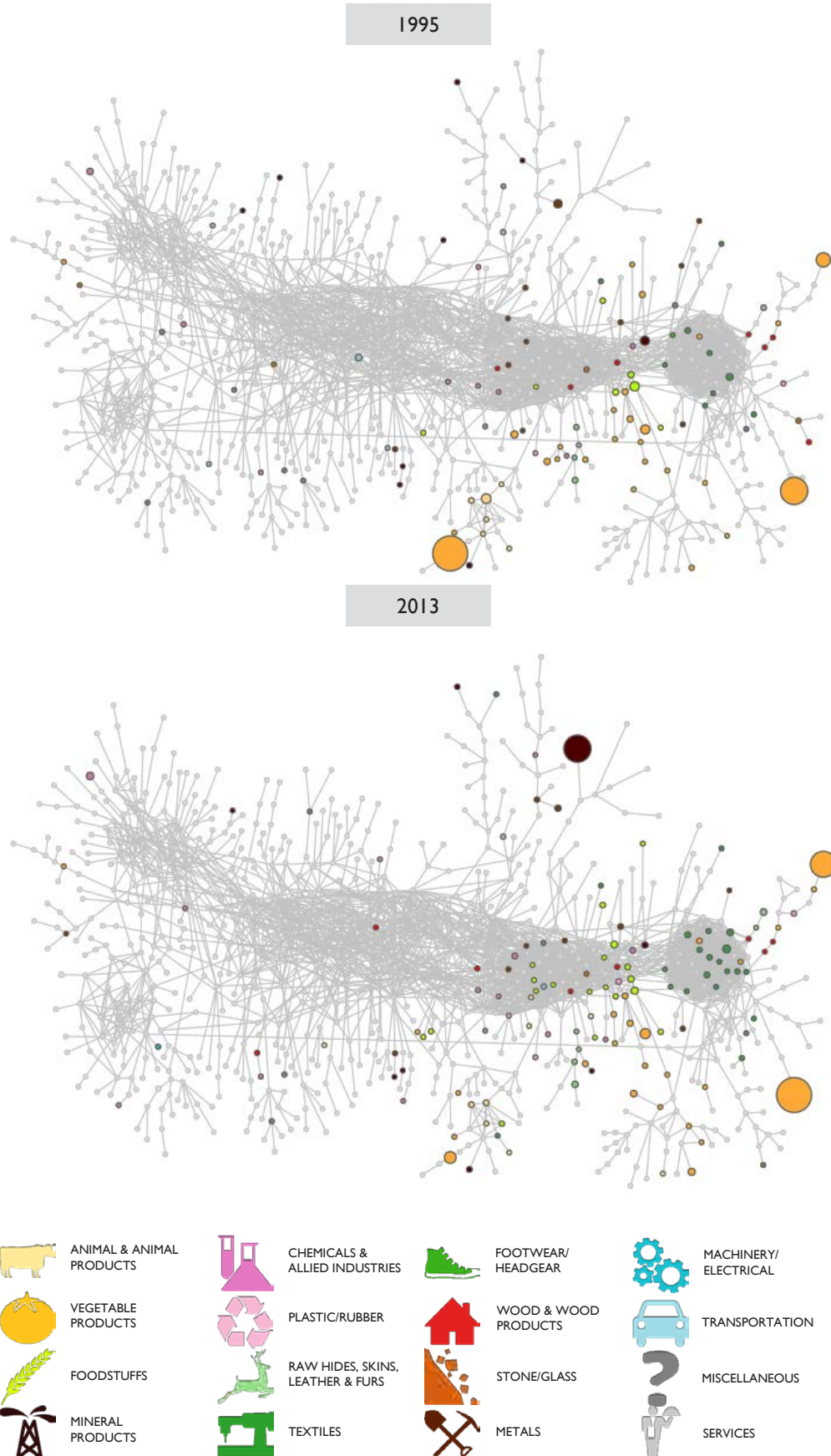


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|---|--------------------------|---|----------------------------------|---|----------------------|---|-----------------------|
|  | ANIMAL & ANIMAL PRODUCTS |  | CHEMICALS & ALLIED INDUSTRIES |  | FOOTWEAR/ HEADGEAR |  | MACHINERY/ ELECTRICAL |
|  | VEGETABLE PRODUCTS |  | PLASTIC/RUBBER |  | WOOD & WOOD PRODUCTS |  | TRANSPORTATION |
|  | FOODSTUFFS |  | RAW HIDES, SKINS, LEATHER & FURS |  | STONE/GLASS |  | MISCELLANEOUS |
|  | MINERAL PRODUCTS |  | TEXTILES |  | METALS |  | SERVICES |

Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

Figure 5: Product Space Kenya, 1995 and 2013

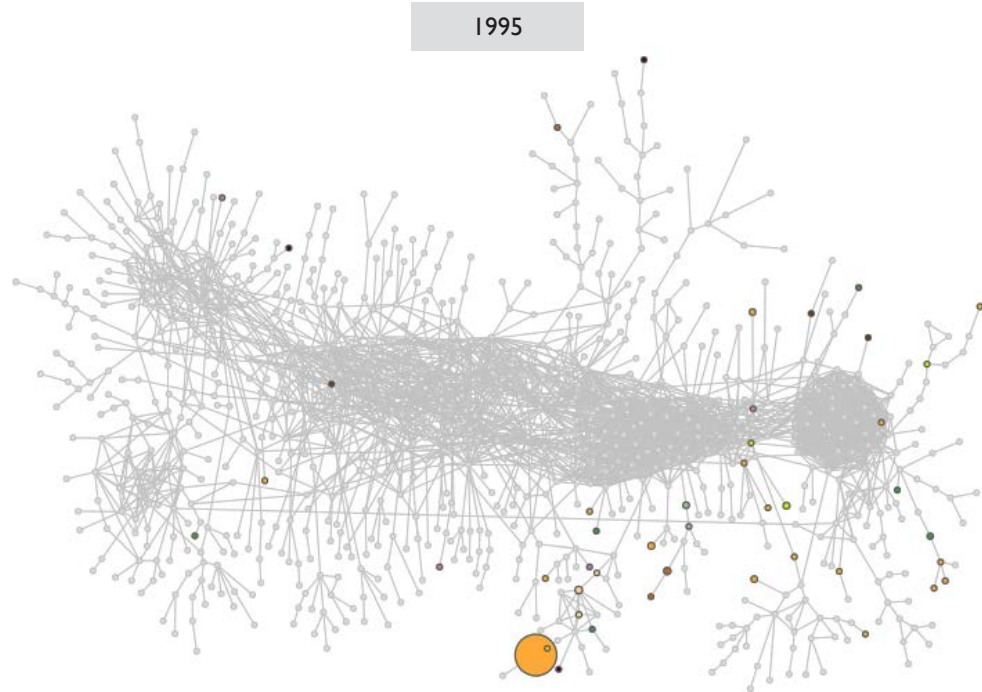
Kenya



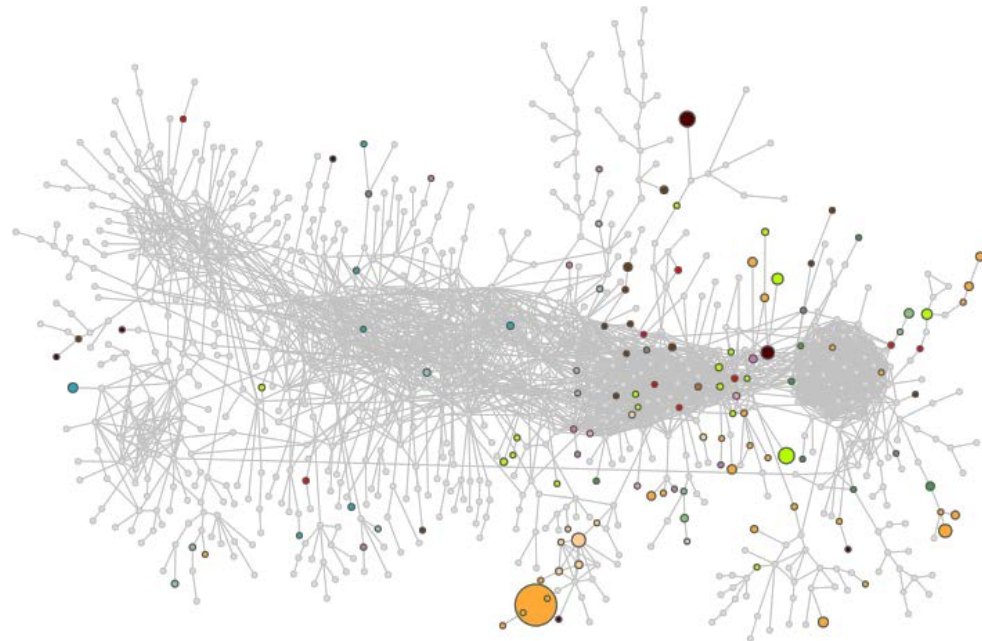
Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

















Figure 6: Product Space Uganda, 1995 and 2013

Uganda



2013

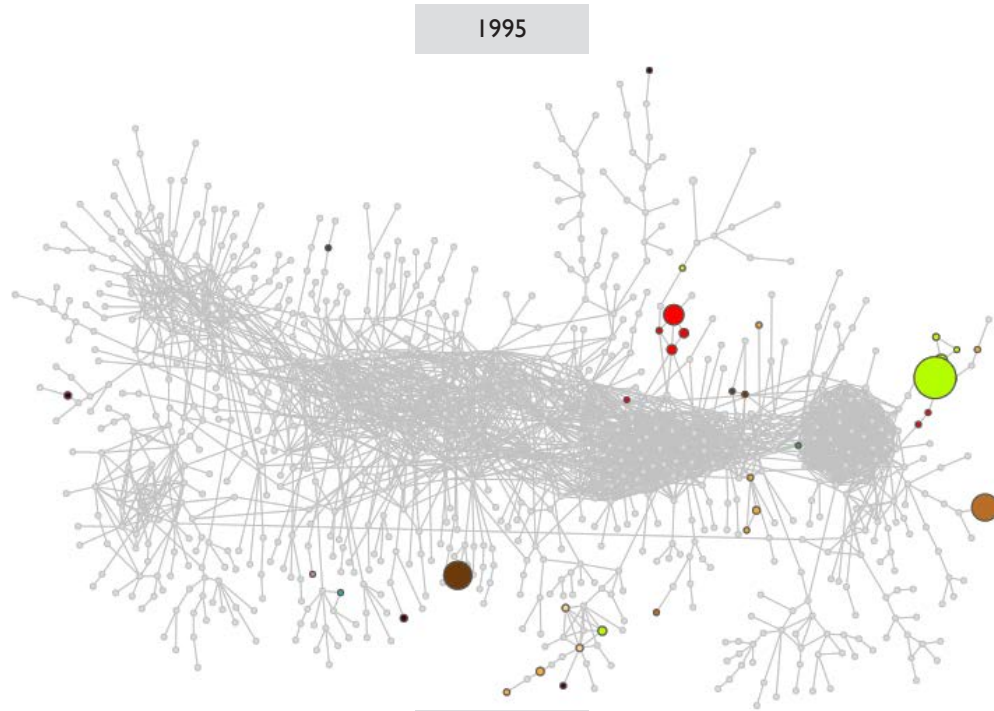


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|  VEGETABLE PRODUCTS |  PLASTIC/RUBBER |  WOOD & WOOD PRODUCTS |  TRANSPORTATION |
|  FOODSTUFFS |  RAW HIDES, SKINS, LEATHER & FURS |  STONE/GLASS |  MISCELLANEOUS |
|  MINERAL PRODUCTS |  TEXTILES |  METALS |  SERVICES |

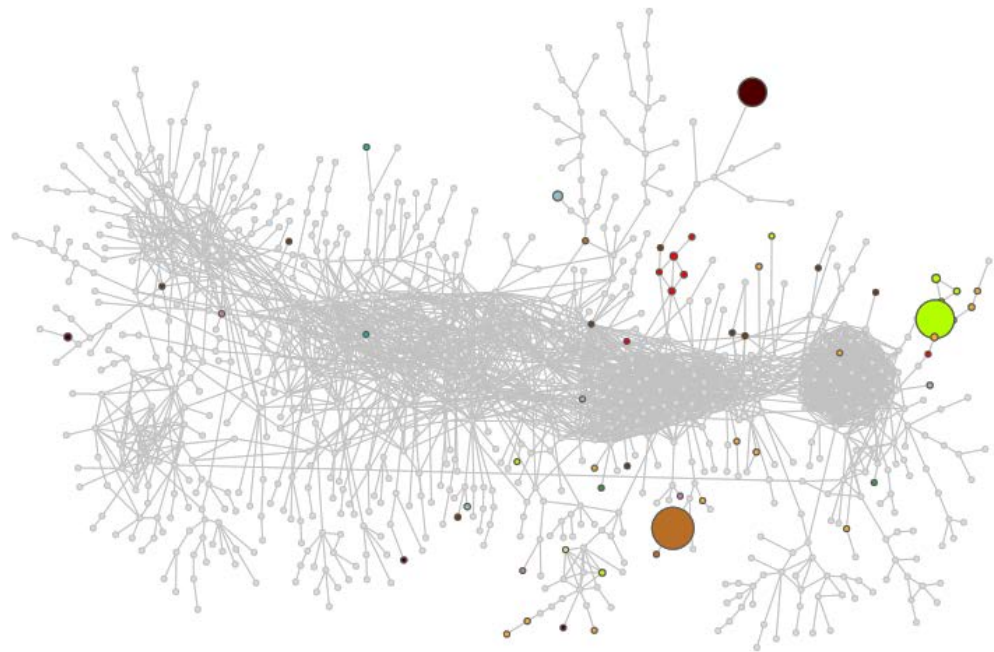
Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

















Figure 7: Product Space Ghana, 1995 and 2013

Ghana



2013

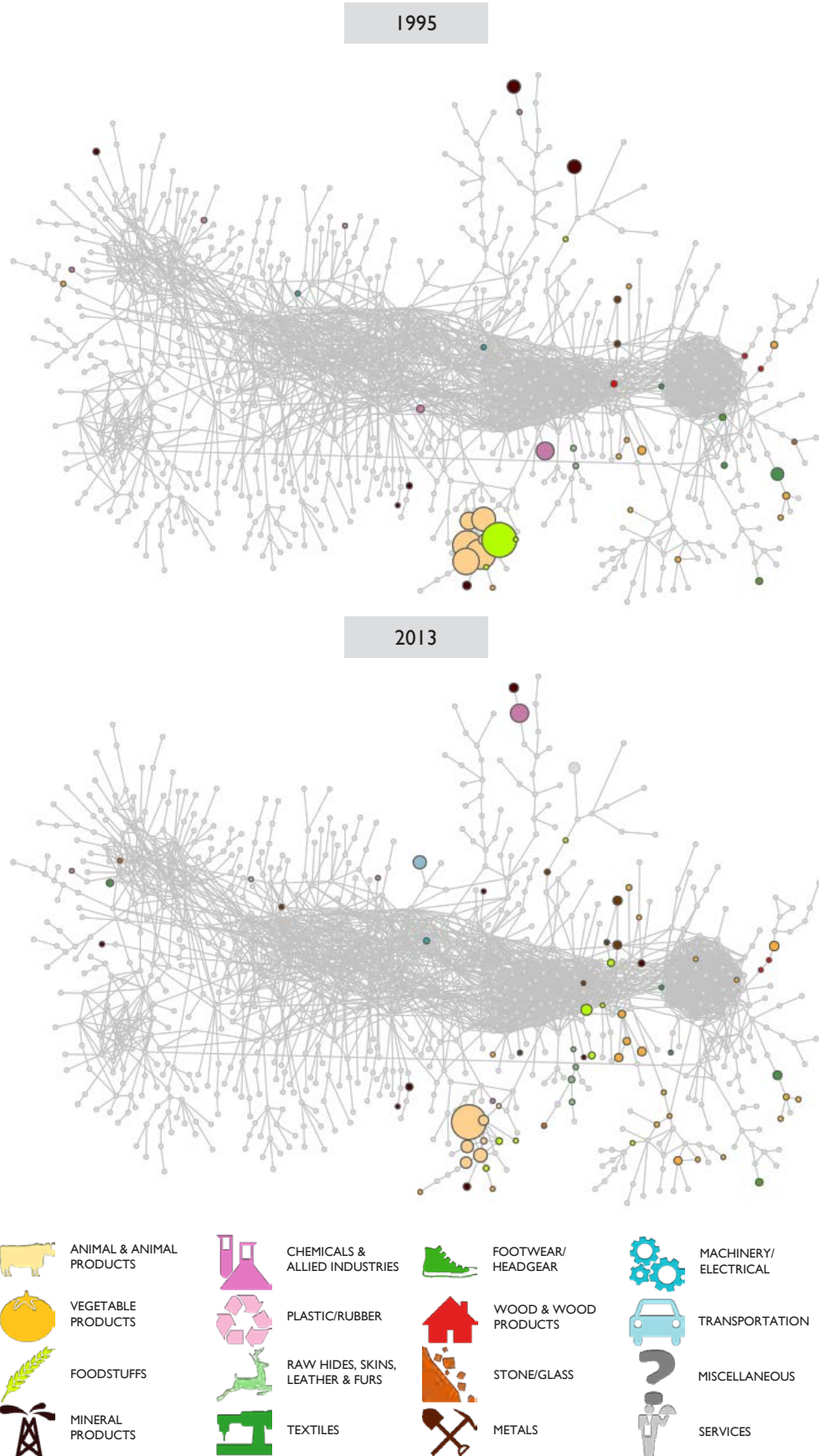


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|  ANIMAL & ANIMAL PRODUCTS |  CHEMICALS & ALLIED INDUSTRIES |  FOOTWEAR/ HEADGEAR |  MACHINERY/ ELECTRICAL |
|  VEGETABLE PRODUCTS |  PLASTIC/RUBBER |  WOOD & WOOD PRODUCTS |  TRANSPORTATION |
|  FOODSTUFFS |  RAW HIDES, SKINS, LEATHER & FURS |  STONE/GLASS |  MISCELLANEOUS |
|  MINERAL PRODUCTS |  TEXTILES |  METALS |  SERVICES |

Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

Figure 8: Product Space Senegal, 1995 and 2013

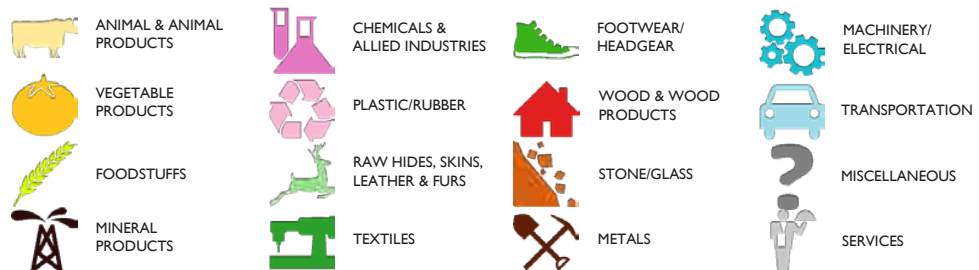
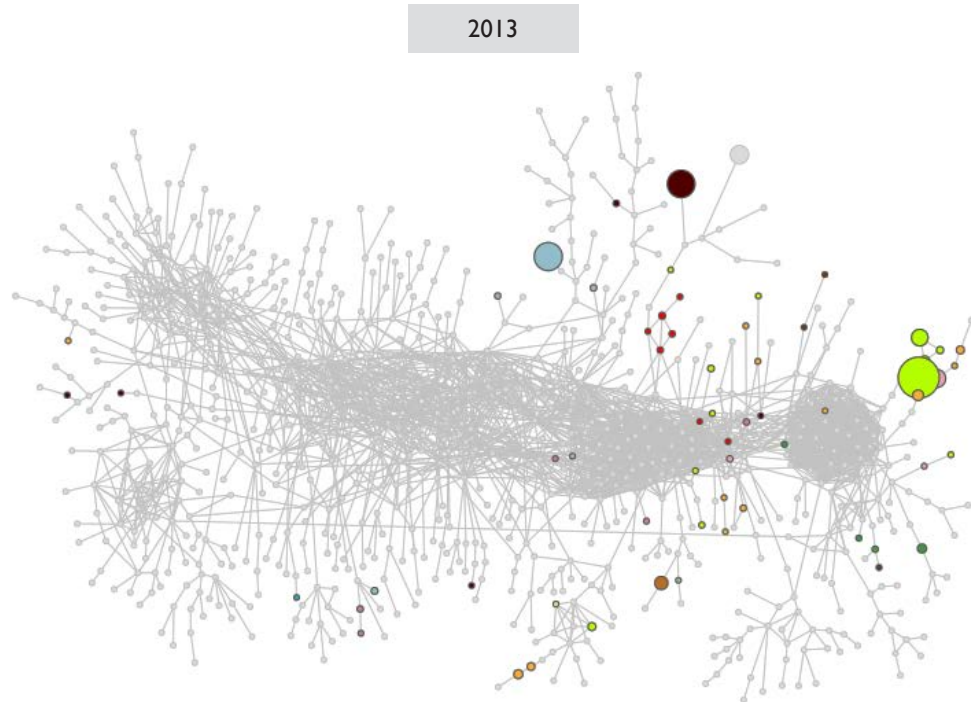
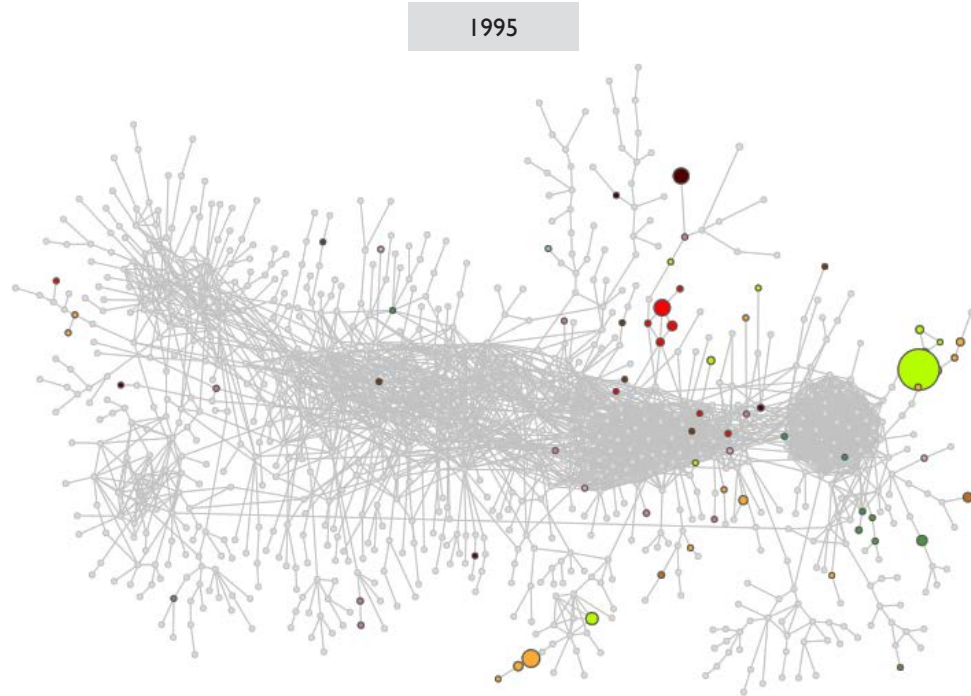
Senegal



Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

Figure 9: Product Space Cote d'Ivoire, 1995 and 2013

Cote
D'Ivoire

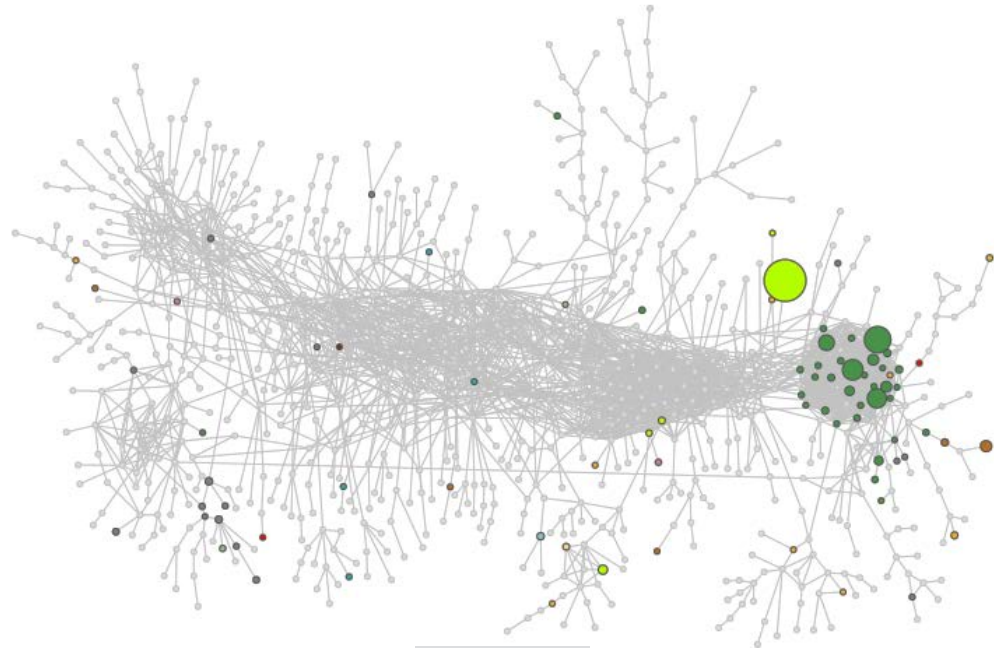


Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

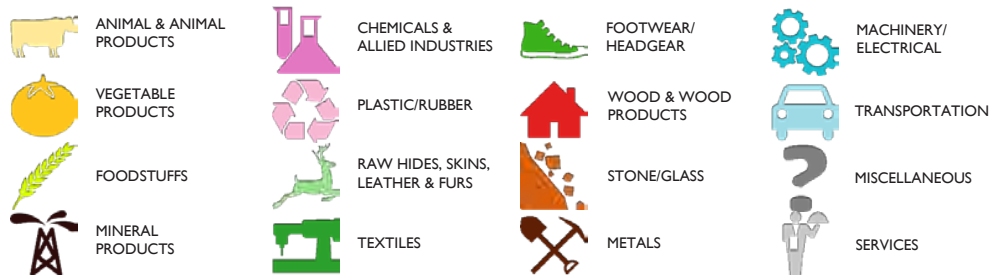
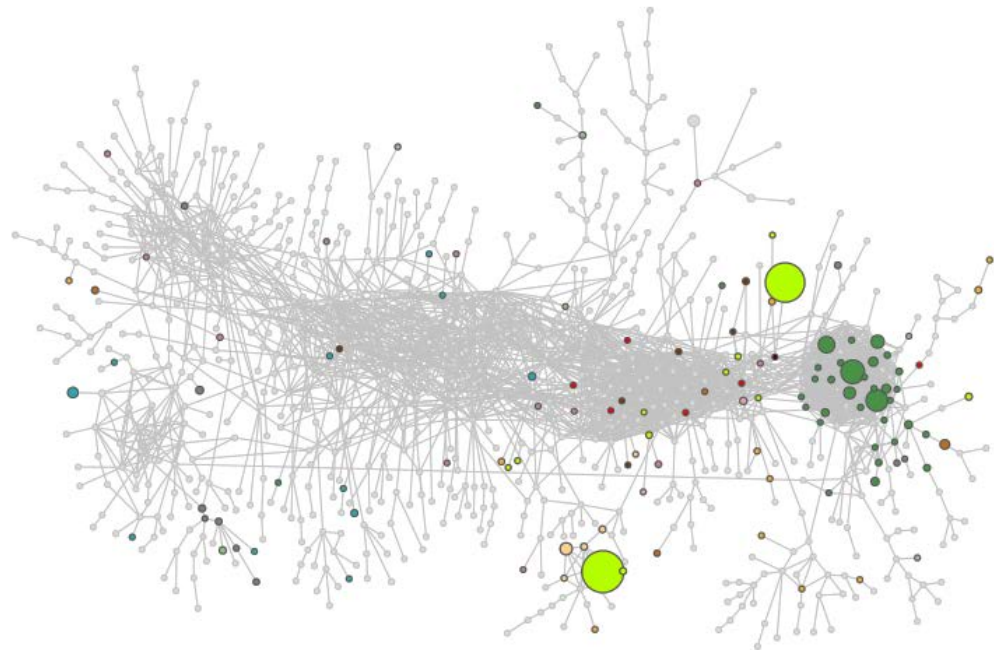
Figure 10: Product Space Mauritius, 1995 and 2013

Mauritius

1995



2013



Source: "The Atlas of Economic Complexity," Centre for International Development at Harvard University, <http://www.atlas.cid.harvard.edu>

With the use of the Atlas of Economic Complexity toolkit, one can also explore the link between the complexity and connectedness of traded products, and what this implies for the process of structural transformation, and of key relevance to this paper, the shift into manufacturing.

The product space framework provides both a visual depiction of the connectedness of a country's export structure as well as a measure of this connectedness (i.e. the opportunity value measure). The framework gives one an idea of the new products that a country can potentially shift into as it undergoes structural transformation. Being located in the highly connected core of the product space makes the process of shifting into new products and growing the complexity of an economy relatively easier. Intuitively, this means that the productive capabilities implied by a country's current productive structure are relatively close to the productive capabilities required in order to shift production into new products. Conversely, being located in the less connected periphery makes the process of shifting into new products and growing the complexity of an economy relatively more difficult. This means that the productive capabilities implied by a country's current productive structure are relatively distant from the productive capabilities required in order to shift production into new products. Hausmann et al. (2011) show that the complexity of products is positively related to their connectedness. As such, producing relatively complex products in the connected core increases the opportunities for further diversification and consequent structural transformation.

Hausmann et al. (2011) provide a measure that captures the value of new productive opportunities associated with a country's current export structure, namely, the opportunity value index (see Box 3). The opportunity value index provides a measure of the opportunities implied by a country's position in the product space. The measure takes into account the level of complexity of the products that the country in question is not currently producing, weighted by how close those products are to the country's current export structure. Hausmann et al. (2011) describe the opportunity value index of a country's export portfolio as such:

"A measure of how many different products are near a country's current set of productive capabilities. Countries with a high opportunity value have an abundance of nearby products due to the make-up of their current export basket. These countries will therefore find it easier to develop new industries and acquire the necessary missing capabilities (productive knowledge) to do so. Countries with a low opportunity value have few nearby products and will find it difficult to acquire new capabilities (productive knowledge) and increase their economic complexity."

Figure 11 depicts the relationship between countries' opportunity value and economic complexity indices. It is evident that higher levels of economic complexity are associated with increased connectedness and greater potential for diversification and hence structural transformation. However, further examination of this link between opportunity value and economic complexity suggests a degree of nuance.

Box 3: The Opportunity Value measure

It is worth further examining the notion of opportunity value and how it is measured in order to gain a clearer understanding of what it means for the analysis in this paper.

Empirically, Hausmann et al. (2011) find that countries move through the product space by developing products close to those that currently comprise their export portfolio. It is also evident that countries export a variety of products that comprise their export portfolio and consequently their export portfolio is proximate to a range of other products that make up the product space. The similarity between two individual products, and as such the similarity in terms of the productive knowledge (or capabilities) required in order to produce them, is labelled 'proximity'. However, Hausmann et al. (2011) are also interested in the aggregate 'proximity' between the products that comprise a country's current export portfolio and the products that it does not currently export. This they term 'distance'.

'Distance' is defined as the sum of proximities connecting a new product p to all the products that country c is not currently exporting. This is normalised by dividing it by the sum of proximities between all products and product p . As such, 'distance' is the weighted proportion of products connected to good p that country c is not exporting, with the weights given by the proximities. Intuitively, the 'distance' measure implies that if country c exports most of the products connected to product p , then the distance will be short, close to 0. Conversely, if country c only exports a small share of the products that are proximate to product p , then the distance will be large, close to 1. This is formally represented by the following equation:

$$d_{c,p} = \frac{\sum_p (1 - M_{c,p'}) \Phi_{p,p'}}{\sum_{p'} \Phi_{p,p'}}$$

Therefore, 'distance' indicates how far each product is, given a country's current export portfolio. Hausmann et al. (2011) go further and generate a measure of the opportunities implied by a country's position within the product space. This measure includes, not only the distance, $d_{c,p}$, to products, but also their complexity. The rationale behind factoring in the complexity of the products that a country does not export is based on the idea that when a country produces products that are relatively complex, given their current level of income, they tend to grow faster.

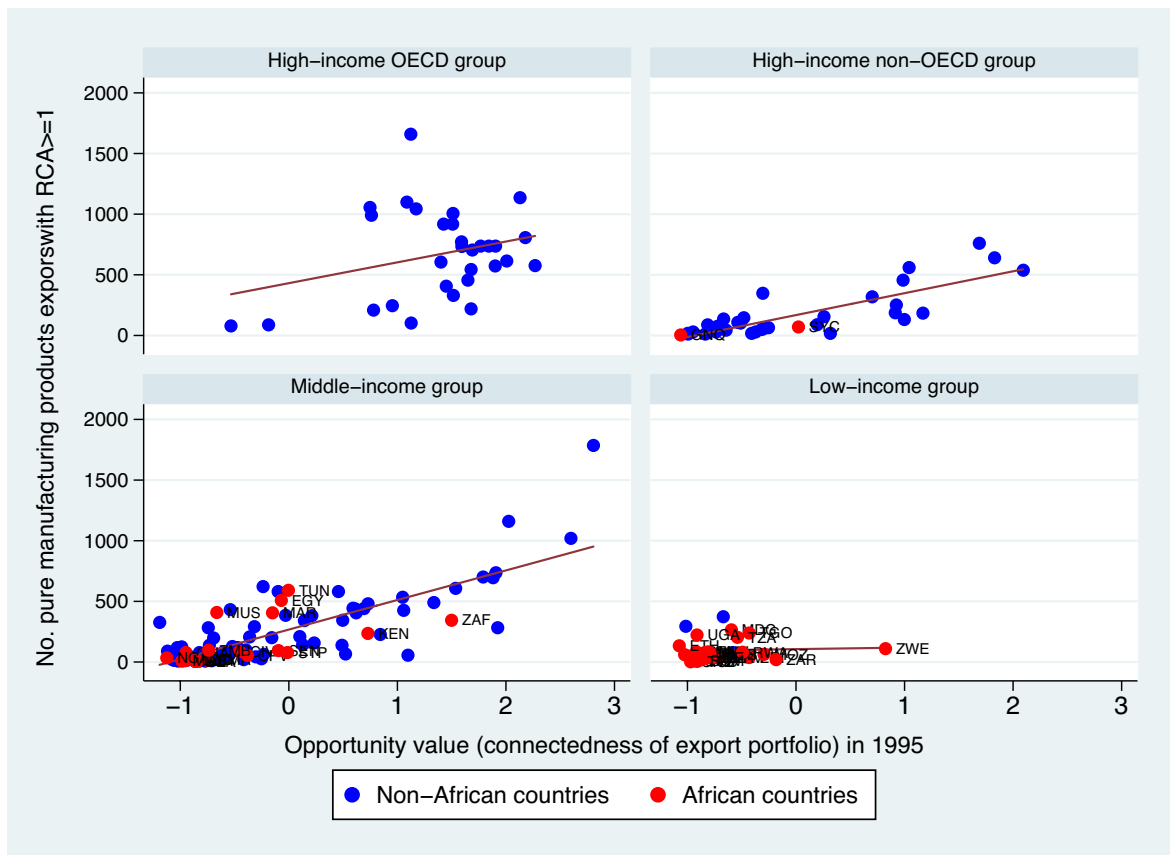
A country's location within the product space has implications in terms of the opportunities available to it in terms of diversification. For instance, some countries are located mainly in the periphery of the product space and thus located next to a few, poorly connected and relatively simple products. Whereas, other countries are located within the core of the product space, next to numerous highly connected and relatively complex products, and hence display a plethora of unexploited opportunities. Therefore, Hausmann et al. (2011) state that countries differ not only in terms of what they produce but also in terms of their productive opportunities. The 'opportunity value' measure is the value of the options or unexploited products available to a country given its current export portfolio. To quantify the 'opportunity value' of a country's unexploited export options, one can add the level of complexity of the products that it is not currently producing, weighted by the distance of these products from a country's current export portfolio. This is formally represented by the following equation:

$$\text{opportunity value}_c = \sum \frac{\Phi_{p,p'}}{\sum_{p'} \Phi_{p,p'}} (1 - M_{c,p'}) \text{PCI}_{p'} - (1 - d_{c,p'}) \text{PCI}_p$$

Where PCI is the product complexity index of product p . A higher opportunity value implies being in the vicinity of more products and/or products that are more complex.

Source: Hausmann et al. (2011) and Hausmann et al. (2014)

Note: $M_{c,p'} = 1$ if country c produces product p , and 0 otherwise.

Figure 12: Opportunity Value in 1995 Pure Manufacturing Exports (RCA \geq 1) in 2013

Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011)

From the African perspective, Figure 12 offers some interesting insights. Firstly, for low income (predominantly African) economies, there is no correlation between the connectedness of their export structures in 1995, and the number of pure manufacturing products that they manufacture in 2013. This scenario suggests that the peripheral nature of their initial productive structure offers little opportunity for diversification into manufactured products.

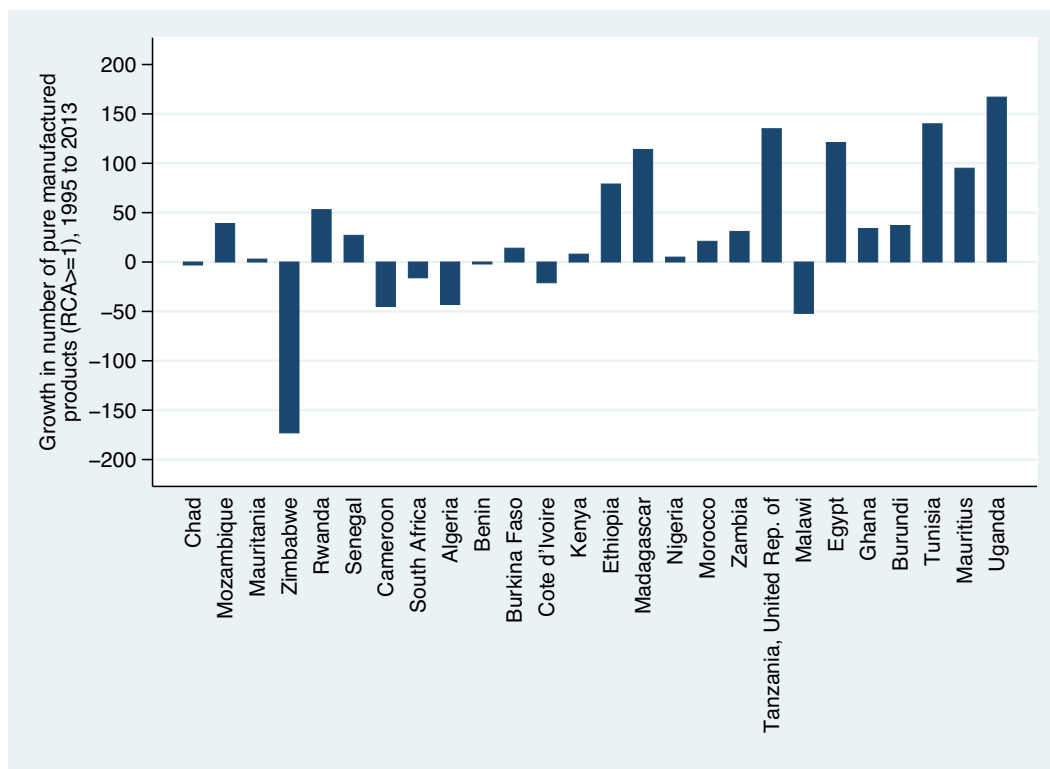
However, in the case of middle-income countries, it is evident that there is a strong positive relationship between the connectedness of their export structure in 1995, and the number of pure manufacturing products that they produce in 2013. This scenario suggests that the initial export structures of these relatively more complex economies, some of which are African, allowed for subsequent diversification into manufactured products.

The low- and middle-income country cases in Figure 12 suggest that there is a non-linear relationship between a country's opportunity value in an initial period, 1995, and the number of pure manufactured products it exports in a latter period. One could argue that this finding suggests that the productive capabilities that embody the export portfolios of these low-income countries is distant from the productive capabilities required in order to produce more complex manufactured products in a latter period. However, in the case of middle-income countries, it seems that an opportunity value threshold, in terms of productive capabilities, has been reached and thus the shift into more complex manufactured products is relatively easier. As such, the process of structural transformation, shifting to more complex manufactured products, is hindered by a country's existing productive capabilities.

We also investigate the link between a country's economic complexity, its opportunity value, and its

manufacturing performance, specifically in the African context, in Figure 13 and Figure 14. Figure 13 shows the growth in the number of pure manufactures over the period 1995 to 2013 for a sample of African countries that are ordered in terms of increasing change to economic complexity. It is evident that growth in the number of pure manufactures is associated with growth in economic complexity. This is particularly evident in countries such as Uganda, Mauritius, Tunisia, Egypt, and Tanzania. As such, it is evident that growth in the productive capabilities needed to produce more complex manufactured products is associated with the growth in manufactures.

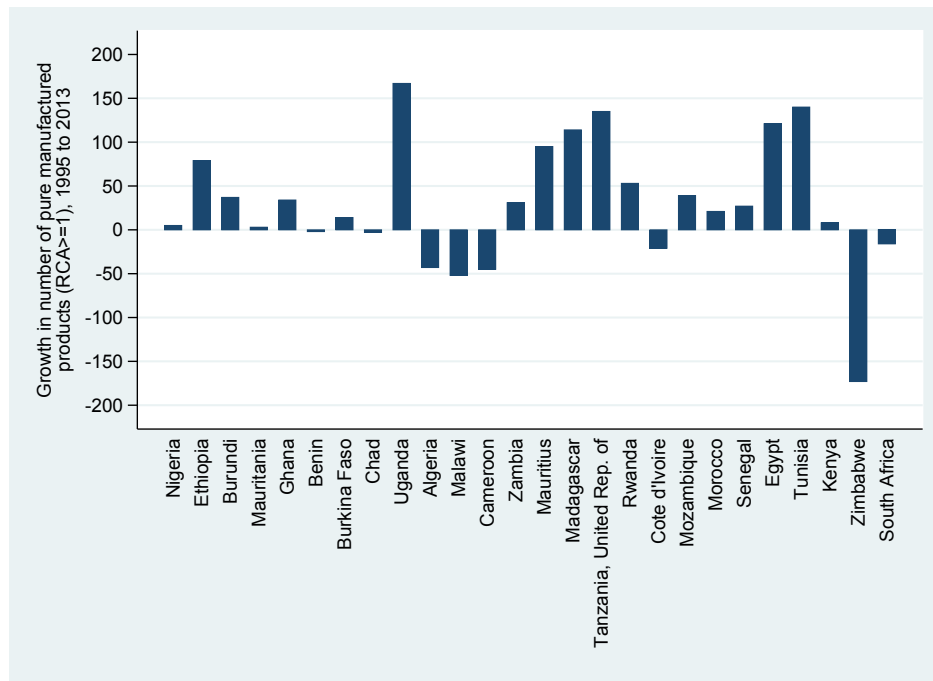
Figure 13: Growth in number of pure manufactures by country in terms of increasing change in economic complexity, 1995 to 2013



Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011)

However, it is also interesting to examine the relationship between a country's opportunity value in an initial period, and the growth in the number of pure manufactures over a period of time. In Figure 14, we show how the growth in pure manufactures over the period 1995 to 2013, across a sample of African countries, is related to the opportunity value of these countries in 1995. Figure 14 suggests a positive relationship but with a number of qualifications. Countries with better-connected export portfolios in 1995 tended to experience greater entry into new pure manufacturing export markets (e.g. Tunisia; Egypt; Tanzania; Madagascar; Mauritius). However, it is also evident that some countries with high opportunity value indices have underperformed, in particular South Africa and Zimbabwe. This latter observation suggests that there are other factors (for example, political or policy-related factors) that may influence a country's pattern of structural transformation despite what its initial export structure offers in terms of potential.

Figure 14: Growth in number of pure manufactures by country in terms of increasing opportunity value in 1995



Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011)

The Atlas of Economic Complexity toolkit and framework developed by Hausmann et al. (2011) and the analysis above suggest that the initial productive structure of an economy, and hence its initial level of productive capabilities, impacts on the number of manufactured products it produces and exports in later periods. This finding implies that the process of structural transformation is a path-dependent process. The export structures of African economies, and hence what the Atlas variables reveal about the structure of these economies, point to these economies being characterised by low levels of economic complexity. The productive capabilities in these economies are limited and basic. This is evident in the depictions of the product space for a sample of African economies, which point to an ‘aggregate African’ product space characterised by primary products in the periphery. This ‘peripheral’ export structure implies that the productive capabilities embodied in export structure of these African economies is distant from the productive capabilities required in order to shift to more complex manufactured products.

However, it is also evident that the African context is heterogeneous and there are a number of African countries that have experienced growth in manufacturing over the past two decades. The analysis suggests that these African economies, for example, Uganda, Tanzania, Madagascar, Mauritius, Tunisia and Egypt, had existing productive structures that embodied a sufficient level of productive capabilities so as to allow for a transition into more complex manufactured products. In Section 5, we examine the extent to which the economic complexity and opportunity value indices explain variation in manufacturing performance across a sample of developed and developing countries, some of which are African countries. In essence, these indices allow us to examine whether the productive capabilities of a country – for example, institutions, infrastructure and the business environment – explain its manufacturing performance.

IV. Methodology and Data Description¹⁰

In this section, we outline our econometric approach and details regarding the specifications that we estimate in Section 5. We also describe the various data that we use in the regression estimations.

4.1 The Econometric Approach

In order to examine the factors that may be constraining the performance of manufacturing in Africa, we employ the following econometric approach: Firstly, we look at whether standard 'Neo-Classical' variables explain variation in manufacturing performance across a sample of both African and non-African countries over time. In this first set of specifications, we control for country factor endowments that would feature in a standard production function, such as capital per worker, technology, and natural resource abundance.

Secondly, we know that country characteristics other than factor endowments, such as institutions, infrastructure, and the business environment, also play a key role in determining manufacturing performance. As such, we need to control for these characteristics. Therefore, in the second set of specifications, we include the economic complexity and opportunity value indices developed by Hausmann et al. (2011) to control for the productive capabilities of a country.¹¹

Thirdly, in order to tease out an 'African effect', we included a dummy variable controlling for African countries in our regressions. Our initial estimations focused on a sample of African countries and we used the fixed effects estimator to examine the determinants of manufacturing performance. However, our initial estimations were problematic for two reasons: Firstly, the data across African countries and over time resulted in a very small sample. Secondly, manufacturing performance across African countries tends to be at the bottom of the cross-country distribution, and thus it seems to be the case that there is too little variation to work with in such a small sample. Therefore, in order to build a larger sample, we included non-African countries. Furthermore, in order to tease out the 'African effect' we included the 'African' dummy variable and employed the random effects estimator. However, this has as a corollary, the fact that it is not possible to employ the fixed effects estimator and control for country and time fixed effects.

Finally, we attempt to unveil whether there is a non-linear relationship between a country's opportunity value index and its manufacturing performance. This is motivated by initial evidence in Figure 12, which suggests that the link between a country's opportunity value and its manufacturing performance varies by country income level. We do this by interacting the opportunity value index with a country income dummy variable. We use four country income level dummies: low-income, middle-income, high-income non-OECD, and high-income OECD.

¹⁰ A description of the dependent and explanatory variables used in the analysis, and the sources of these data are provided in Appendix Table 4.

¹¹ It is worth noting that we have run specifications where we regress a number of country-level variables on measures of manufacturing performance. These country levels include measures of infrastructure, institutions, business environment, trade barriers, geography and the like. However, these specifications were problematic and failed to generate any meaningful results. We believe the reasons for the problems relating to these regressions are as follows (but not limited to): Firstly, developing a suitably populated cross-country panel is difficult due to poor data for a large number of developing countries, especially African countries. This resulted in a small sample of countries over a short period of time, which limited the explanatory power of our estimations. Secondly, the variables controlling for various country characteristics are, in some cases, highly collinear and this adversely affects the accuracy and consistency of the estimates.

4.2 Specification

In order to examine the factors constraining manufacturing performance, with specific focus on African countries, we estimate the following reduced form equation using the random effects estimator:

$$M_{ct} = \alpha_c + \beta_1 \text{Neoclassical}_{ct} + \beta_2 \text{Africa}_c + \beta_3 \text{Productive structure}_{ct} + \mu_{ct}$$

Where M_{ct} is a measure of manufacturing performance in country c in year t . Neoclassical_{ct} denotes the 'Neo-Classical' variables controlling for factor endowments in country c in year t . $\text{Productive structure}_{ct}$ denotes variables from the Hausmann et al. (2011) Atlas of Economic Complexity, which control for the productive capabilities of an economy. Africa_c is the dummy variable controlling for whether a country is located in Africa. Finally, μ_{ct} is the composite error term.

4.3 Measuring Manufacturing Performance: The Dependent Variable

There are a number of ways one can measure manufacturing performance: manufacturing output as a share of GDP, the ratio of manufacturing exports to total exports, and the natural log of the count of manufacturing products exported. In our estimations, we employ the latter. We choose this variable because it is consistent with the product space framework where growth is measured by increased colonisation of the various nodes that comprise the product space. It is important to note that, when using the count of manufacturing products exported, we are defining export performance as the diversification of a country's export structure.

A further motivation for using an export measure of manufacturing is that the export of manufactured products is a better measure of the strength of a country's manufacturing sector, since the ability to enter and compete in global markets indicates manufacturing proficiency. It is also worth noting that we run specifications for both pure manufacturing and total manufacturing products.¹³

4.4 Explanatory Variables

As discussed above, we include two groups of explanatory variables:

a) 'Neo-Classical' or Factor Endowment Variables

These variables control for the 'standard neoclassical' explanation for a country's productive structure where a production function is used to describe what a country produces. The 'neoclassical' explanation of a country's productive structure suggests that what a country produces is determined by its factor endowments. In the estimations reported below, we control for the following factor endowments such as: capital per worker, total factor productivity, and natural resource abundance.

b) Structure of Production

In the second set of regressions we include measures taken from the Atlas of Economic Complexity developed by Hausmann et al. (2011). As discussed in Section 3, the extent to which an economy is able to diversify into more complex manufacturing products is influenced by the productive capabilities present within an economy (i.e. economic complexity). Furthermore, the ability to diversify into more complex manufacturing products is also influenced by the distance a country's current productive capabilities are from those required to shift into more complex manufacturing products (i.e. opportunity value). Therefore, we expect that higher levels of economic complexity and opportunity value are associated with better manufacturing performance.

In the next section we report the results of our estimations.

¹² Data availability along the country and time dimensions is a key complication in cross-country studies focused on African countries. In compiling a dataset for a variety of country characteristics, we found that roughly half of the African countries had fairly good data coverage over time (this is not a statement on the quality of the data), while data for the other half was patchy at best.

V. Estimating the Determinants of Africa's Manufacturing Performance

In this section, we undertake to analyse what factors may be constraining the performance of the manufacturing sector in Africa within a multivariate context. To the extent that manufacturing sector growth is key to growth-enhancing structural transformation, it follows that understanding the factors constraining growth in the sector is of prime importance. As described in Section 4, in order to unpack what factors may be constraining manufacturing performance in Africa, we estimate two broad specifications. We start with the 'Neo-Classical' specification.

5.1 Explaining Manufacturing Performance: The 'Neo-Classical' Specification

The estimates for the 'Neo-Classical' specifications reported in Table 1 allow one to assess the extent to which endowments determine a country's manufacturing performance. The estimations use the natural log of the count of exported products in total manufacturing to measure manufacturing performance. In each of the specifications, we control for employment, capital stock, technology, and natural resource abundance. The random effects estimation technique is employed in order to run regressions on an unbalanced panel of cross-country data for the period 1995 to 2013.

The positive and statistically significant coefficients for the log of capital per worker variable indicate that the more capital per worker in a country, the greater the number of manufactured products a country produces. This finding is consistent in the case of total as well as pure manufactures. This is expected, since manufacturing processes typically require relatively higher levels of capital per worker. This does suggest that the extent to which financial capital markets restrict or enable firms to access credit to finance physical capital investment may be an important constraint to manufacturing growth in African countries.

Table 1: Explaining Manufacturing Performance in Africa, 1995-2013: The 'Neo-Classical' Specification

	Log of product count of Total Manufacturing exports
Log of fixed capital per worker	0.255*** [0.050]
Total factor productivity	0.131 [0.091]
Total natural resources rents (% of GDP)	0.002 [0.002]
Africa	-0.392* [0.219]
Constant	4.847*** [0.618]
Observations	1,750
Number of groups	104
R-squared overall	0.420

Notes: 1. Robust standard errors in brackets. 2. *** p<0.01, ** p<0.05, * p<0.1 3. PM = Pure manufacturing; TM = Total manufacturing. Pure manufacturing exports refer to low-, medium-, and high-technology manufactures, whereas total manufacturing refers to the sum of pure manufactures and resource-based manufactures. 4. 'Total natural resource rents' is used as a proxy for natural resource abundance in a country. 5. 'Africa' is a dummy variable controlling for whether a country is an African country. 6. The 'total factor productivity', the variable used to control for technology, is measured using current PPPs with USA=1.

The estimated coefficients of the measures controlling for technology and natural resource abundance are both positive but not statistically significant across both specifications. This suggests that these two factor endowments that typically feature in production function equations are not explaining variation in manufacturing performance across countries over time.

Interestingly, the dummy variable controlling for African countries is negative and statistically significant. This suggests that if there are two identical countries, in terms of endowments, and one is African and the other is from another region, then the African country underperforms. It is likely that there are unobservable country characteristics that these specifications are not picking up. For instance, it is possible that there is an 'African effect' with regard to foreign investor perceptions that results in less manufacturing-focused FDI going to African countries.

Nevertheless, there is a range of other country characteristics, beyond factor endowments, that may shape a country's manufacturing performance. We examine these country characteristics in the sub-section to follow.

5.2 Explaining Manufacturing Performance: Atlas Variable Specification

In Table 2 we report the results for the specification where we investigate whether the Atlas variables developed by Hausmann et al. (2011) explain manufacturing performance across a sample of countries over the period 1995 to 2013.¹⁵ These specifications extend the 'Neo-classical' specification by including the opportunity value and economic complexity measures. Column two shows this estimation, while column three extends the analysis by teasing out whether there is evidence of non-linearity in terms of how the opportunity value influences manufacturing performance across income levels. These specifications are estimated using the random effects estimator.

Consistent with the 'Neo-Classical' specification, the estimated coefficient for the capital stock per worker variable is positive and statistically significant. Again, this indicates the importance of a country's endowment of physical capital in explaining its manufacturing performance.

Contrary to the estimates in the 'Neo-Classical' specification, the total factor productivity variable that controls for the technology level in a country is now statistically significant and positive. This result makes sense since the production process behind manufactures requires certain technologies, and those countries best able to acquire these technologies (via domestic development or import of technologies) are best placed to develop their manufacturing sector. Lall (2000) disaggregates manufactures into low- medium- and high-technology products, and argues that the economic success of the East Asian Tigers countries is partly explained by their ability to shift from low-technology manufactures to medium- and high-technology manufactures.

Shifting focus to the economic complexity index variable, the estimated coefficient is negative and not statistically significant. This may be driven by the fact that countries with the highest levels of economic complexity tend to be high-income countries. Although typically possessing an advanced manufacturing sector, high-income countries tend to shift to the services sector as they develop, while the manufacturing sector plays an increasingly lesser role. In particular, there is evidence of the manufacturing sector in high-income countries reducing in size in the face of significant growth in manufacturing in emerging markets, particularly China (for example, see Fontagne et al., 2008).

¹⁵ The sample of countries is determined by data availability. The sample is comprised of 104 countries, 21 of which are African countries. The African countries include: Benin, Burundi, Cameroon, Central African Republic, Cote d'Ivoire, Egypt, Kenya, Mauritania, Mauritius, Morocco, Mozambique, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Tunisia, Zimbabwe. The sample is reduced by 55 countries because of the limited coverage for the total factor productivity measure and as such one may need to generate an alternative measure to control for technology that may have better coverage across countries.

¹⁶ Similar results were obtained when the dependent variable measured pure manufacturing exports.

The opportunity value index variable is a measure of how many different products are near a country's current set of productive capabilities. A higher opportunity value index indicates that a country's current export portfolio is proximate to a large number of products, and hence its export portfolio is likely to be comprised of a large number of 'connected' manufacturing products in the core of the product space. A country with a higher opportunity value index will find it easier to acquire the necessary productive capabilities needed in order to develop new industries and products, particularly manufactures, because the required productive capabilities are proximate to its existing productive capabilities.

The results in Table 2 show that the opportunity value index is positive and statistically significant, thus indicating the more connected a country's export structure, the better its manufacturing performance. This suggests that the productive capabilities of a country, embodied in its existing export portfolio is a key constraint to its manufacturing performance. The fundamental notion behind this estimate is that countries whose productive capabilities are nearest to those needed to produce a greater range of manufactures are those whose manufacturing performance is best.¹⁷

Interestingly, once we control for the connectedness of a country's export structure and its economic complexity, the negative 'Africa effect' falls away.¹⁸ This implies that once we control for the productive capabilities of a country and the potential these capabilities offer in terms of ability to shift to increased manufacturing activity, the manufacturing sectors in African countries do not underperform relative to those in countries from other regions. Therefore, if African countries are able to develop the appropriate productive capabilities needed for a dynamic manufacturing sector, then manufacturing firms in these countries would be able to compete in the global market.

From a policy standpoint, it is important to identify these productive capabilities. However, in light of the heterogeneity of African countries and the notion that Africa is not one big country, case-study type analyses would be best served to identify the specific constraints faced by manufacturing firms within individual African countries.

Finally, the estimates reported in column three of Table 2 attempt to tease out whether the link between the connectedness of countries' export portfolios and their manufacturing performance is non-linear by income. The positive but not statistically significant coefficient for the Opportunity value index * Low income country dummy interaction term suggests that connectedness of these countries does not affect their export performance. This may be due to the manufacturing sectors in these countries being close to non-existent.

It is evident that the estimated coefficients for the interaction terms pertaining to middle-income, high-income OECD, and high-income non-OECD countries, are all positive and statistically significant. This suggests that the connectedness of the export structures of these countries is positively related to their manufacturing performance.

¹⁷ It is worth noting that future iterations of this regression will seek to estimate the effect of a country's initial opportunity value index (say in 1995) – and hence its initial potential to diversify into increased manufacturing activity against its subsequent manufacturing performance.

¹⁸ In light of the 'Africa dummy' not being statistically significant, we also run this specification using the fixed effects estimator in order to control for country and year-fixed effects. The results using the fixed effects estimator are consistent with those reported in Table 2 (see Appendix Table 4)

Table 2: Explaining Manufacturing Performance over the Period 1995 to 2013: Hausmann et al. (2011) Atlas Variable Specification

	Log of product count of TM exports	Log of product count of TM exports
Log of fixed capital per worker	0.261*** [0.053]	0.247*** [0.056]
Total factor productivity	0.152* [0.085]	0.190** [0.085]
Total natural resources rents (% of GDP)	0.003 [0.002]	0.002 [0.002]
Africa	-0.272 [0.198]	-0.266 [0.180]
Economic complexity index	-0.026 [0.064]	-0.044 [0.056]
Opportunity value index	0.151*** [0.033]	
Opportunity value index * Low income country dummy		0.361 [0.246]
Opportunity value index * Middle income country dummy		0.227*** [0.060]
Opportunity value index * High income OECD country dummy		0.095*** [0.024]
Opportunity value index * High income non-OECD country dummy		0.139* [0.081]
Constant	4.670*** [0.631]	4.827*** [0.653]
Observations	1,750	1,750
Number of groups	104	104
R-squared overall	0.553	0.602

Notes: 1. Robust standard errors in brackets. 2. *** p<0.01, ** p<0.05, * p<0.1 3. PM = Pure manufacturing; TM = Total manufacturing. Pure manufacturing exports refer to low-, medium-, and high-technology manufactures, whereas total manufacturing refers to the sum of pure manufactures and resource-based manufactures. 4. 'Total natural resource rents' is used as a proxy for natural resource abundance in a country. 5. 'Africa' is a dummy variable controlling for whether a country is an African country. 6. The 'total factor productivity', the variable used to control for technology, is measured using current PPPs with USA=1.

Interestingly, one notices that the magnitude of the estimated coefficients increases as one moves from high-income OECD to high-income non-OECD, to middle-income countries with the implication being that middle-income countries reap greater dividends in terms of improved manufacturing performance with respect to the connectedness of their export portfolios. Intuitively, this makes sense since middle-income countries with the requisite productive capabilities have greater scope for expansion into new manufacturing products and hence manufacturing growth (i.e. they start from a lower base, and there are a lot more 'easy wins'). Conversely, high-income countries have established manufacturing sectors, and consequently the scope for expansion into new manufacturing activities is limited.

Furthermore, this result seems consistent with studies that examine the link between export diversification and economic development (Cadot et al., 2011; Klinger & Lederman, 2011). Typically, these studies show that as countries develop, they diversify their export structures and manufacture more products. As countries reach higher levels of development, they shift to services, and manufacturing growth levels off. In terms of the potential for manufacturing growth in African countries, this result offers solace, since a small number of African countries have recently shifted to middle-income country status. These countries seem to evidence the greatest potential when it comes to developing their manufacturing sectors.

VI. Conclusion and Policy Recommendations

The above has essentially tabled a view that structural transformation is principally about the steady diversification over time of a domestic economy into increasingly sophisticated forms of manufacturing activities and output. Therefore, understanding the factors that may be constraining this steady growth in manufacturing production is of key importance.

The analysis in Section 3 indicates that although Africa has undergone structural transformation over the past few decades, such structural change has not followed the 'East Asian model' where resources have shifted from low productivity agricultural activities into higher productivity manufacturing activities. Instead, we see that in the African case, resources have shifted away from low-productivity agricultural activities toward the services sector. Therefore, the process of structural transformation in Africa seems to have obviated the apparent need – within a period of high growth rates in many African economies – for a phase of economic development wherein manufacturing is the life-blood of economic growth and national output.

Using the analytical and empirical toolkit offered by the Atlas of Economic Complexity, we show that productive capabilities in Africa remain relatively low, and that this has in turn translated into low levels of economic development. The product space analysis shows us that the export portfolios of African economies are peripheral and consequently dominated by primary products. The opportunity value index indicates that the peripheral nature of the African export portfolio has implications for the region's ability to structurally transform itself. It is clear that the productive capabilities that are embodied in the productive structure of a typical African economy are distant from the productive capabilities required in order to shift production toward more complex manufacturing activities.

In light of generally poor manufacturing performance across African countries, we consider possible constraints to the development and growth of a manufacturing sector. We consider the importance of a country's factor endowments in providing the initial economic landscape for the development of manufacturing.

The econometric analysis in Section 5 suggests that factor endowments such as physical capital per worker impact positively on manufacturing performance across countries over time. On the other hand, we observe that being a country located in Africa has a negative effect on manufacturing performance, and this result is consistent across all specifications. The latter result suggests that even after controlling for a range of factors, there are some other unobservable variables which are affecting Africa's manufacturing performance negatively.

Interestingly, the opportunity value variable, and hence what it embodies, is a significant determinant of manufacturing performance. The smaller the distance between a country's current set of productive capabilities and those required in order to shift into manufactured products, are associated with higher levels of manufacturing performance. Furthermore, once we control for a country's economic complexity and the connectedness of its export structure, the negative 'Africa effect' falls away. This fact dispels the notion of a negative perception of 'African manufacturers'.

With regards to opportunity value, we see that there is a non-linear effect. Specifically, we see that the positive effect is increasing in magnitude as one moves from high-income to middle-income countries. This finding suggests that middle-income countries have the most to gain from investing in their productive capabilities. However, in the case of low-income countries, there is no statistically significant effect. This may be due to the manufacturing sectors in these countries being non-existent and thus their existing productive capabilities inherent in their productive structure are too far from the productive capabilities needed in order to easily diversify into manufacturing products.

The importance of productive capabilities seems to suggest that providing an environment that facilitates the development of the manufacturing sector requires a combination of factors (i.e. infrastructure, institutions, business environment etc.). This aligns with the Hausmann et al. (2011) scrabble piece analogy, which suggests that only once one has amassed enough letters (i.e. productive capabilities) can one start to build complex words (i.e. develop complex manufactures). In other words, only once there is a consistent supply of electricity in the industrial areas, and a road from the industrial area to the port, with no police road blocks requiring bribes, and an efficient export processing zone with minimum costs and procedures involved in the process of exporting, and the like, can manufacturing firms enter the market and start to produce on a substantial scale.

Given the large number of public inputs required for a vibrant manufacturing sector as well as the heterogeneity between African countries, we adopt the approach of Hausmann et al. (2014) in detailing policy prescriptions. In essence, Hausmann et al. (2014) surmise that individual firms are best-placed to recognise the specific constraints that they experience in conducting business and that it would be more worthwhile to provide policy recommendations which strengthen the relationship between the private sector and government to identify problems and provide solutions.

The first recommendation provided by Hausmann et al. (2014) is to increase the 'bandwidth' between the private sector and government. Bandwidth refers to the frequency and detail of information that flows between the private sector and government. The private sector can aid the government in identifying impediments to growth – such as a lack of internet sector – while the government can provide the public inputs needed for growth. To increase the 'bandwidth', Hausmann et al. (2014) assert that working groups – comprised of industry representatives and government – should meet on regular occasions to engage with each other. Industry representatives should reflect the entire sector as otherwise a small group of powerful firms might request certain arrangements – such as higher subsidies – which benefit them, and not the industry as a whole (Hausmann et al., 2014).

A second policy recommendation is that of creating a government-financed venture capital fund (Hausmann et al., 2014). In return for providing finance to new firms, the government can gain valuable insight into the challenges faced by these entrepreneurs. For example, in South Africa, over 80 percent of new businesses close within three years (Mafoyané, 2015). The government can analyse whether the closures were largely due to the business itself (e.g. poor marketing) or due to the macro-environment. If the business closed due to the latter factor, the government could attempt to resolve the problem(s), and thereby produce an environment that is more conducive to business.

A third policy recommendation advocated by Hausmann et al. (2014) is the creation of an annual competitiveness bill. For the two policy recommendations above, there is an implicit assumption that the government will act upon the information given to it by private business. If the government does not act upon the information, then private business will regard the process as a futile exercise and withdraw. To overcome this potential challenge, Hausmann et al. (2014) suggest that parliament should create an annual competitiveness bill, where all reasonable suggestions from the various working groups are included. The process must be transparent, and only proposals which are of public benefit should be included. The creation or the upgrade of public inputs must be a priority in these bills.

Fourthly, it is vital that co-ordination between various governments departments is improved (Hausmann et al., 2014). In many cases, the department that identifies the problem is different to the one that can solve the problem. For example, small business owners might report a lack of broadband provision to the Minister in charge of Small and Medium Enterprises (SMEs). However, the department that can solve this problem is the Telecommunications Ministry. The various government departments have different priorities, however, and what might be a priority for one department might not be a priority for the other department. Inevitably, such a scenario results in the problem not getting solved.

To overcome this challenge, Hausmann et al. (2014) suggest that a central government fund i be created. Each year, a certain amount of money will be allocated to this fund, and departments which have identified problems can make submissions to the fund. The submission will include important details such as the department responsible for resolving the problem as well as the budget allocation. An additional benefit of the fund is that the departments which are responsible for fixing the problem will not have to use their own budget to do so.

A final policy recommendation is the creation of industrial policy zones (Hausmann et al., 2014). As noted earlier, for a country to develop a viable industry, many critical public inputs are required. However, for many developing countries, especially the many poor ones in Africa, it is unfeasible to provide these inputs to everybody. Not only can these governments not afford to do so, but even if they could, the development of the public inputs would take an extraordinary length of time.

Industrial policy zones are an answer to this problem, as they are relatively small areas where many businesses are located. This allows governments to provide the critical public inputs to a relatively large number of businesses. Businesses can also benefit through interacting with other businesses (e.g. skills transfer and agglomeration effects). As with the workshops, government can learn from the challenges faced by businesses in the industrial development zone and make changes as required.

In closing, it is important to realise that although the policy prescriptions can certainly be applied to all African countries, there is no 'magic bullet' for Africa. In fact, each country's issues are more nuanced than presented in this study. It is likely that country-focused studies will yield more specific and desirable policy options.

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Appendices

Appendix Table 1: Economic Complexity, Opportunity Value, and Change in No. Pure Manufacturing Exports, 1995 to 2013

Country	ECI 1995	ECI 2013	Change in ECI (1995-2013)	Opportunity value (1995)	Change in no. PM exports (RCA>=1)	
Uganda*	-1,36	-0,65	0,71	-0,91	167	
Mauritius*	-0,71	-0,10	0,61	-0,66	95	
Tunisia	-0,41	0,17	0,58	0,00	140	594
Burundi	-1,47	-0,90	0,57	-1,03	37	
Ghana*	-1,43	-0,96	0,48	-0,95	34	
Egypt	-0,54	-0,17	0,38	-0,07	121	
Malawi	-1,20	-0,87	0,33	-0,81	-52	
Tanzania	-1,24	-0,95	0,29	-0,54	135	
Zambia	-0,68	-0,42	0,25	-0,74	31	219
Morocco	-0,78	-0,53	0,25	-0,15	21	
Nigeria*	-2,12	-1,89	0,24	-1,12	5	
Ethiopia*	-1,53	-1,42	0,11	-1,08	79	
Madagascar	-1,21	-1,10	0,10	-0,60	114	
Kenya*	-0,45	-0,43	0,02	0,73	8	
Cote d'Ivoire*	-1,00	-1,04	-0,04	-0,45	-21	
Burkina Faso	-0,83	-1,05	-0,22	-0,91	14	54
Benin	-0,80	-1,06	-0,26	-0,92	-2	
Algeria*	-0,69	-0,97	-0,28	-0,86	-43	
South Africa*	0,20	-0,09	-0,29	1,50	-16	
Cameroon	-1,06	-1,45	-0,39	-0,76	-45	
Senegal*	-0,22	-0,66	-0,44	-0,10	27	
Rwanda	0,12	-0,44	-0,56	-0,49	53	
Zimbabwe	-0,25	-0,85	-0,60	0,82	-173	-99
Mauritania	-1,24	-1,93	-0,69	-0,98	3	
Mozambique*	-0,49	-1,21	-0,72	-0,29	39	
Chad	-0,73	-2,75	-2,03	-0,91	-3	

Source: Own calculation using data from The Economic Complexity Observatory (Simoes & Hidalgo, 2011).

Note: * indicates countries depicted in product space graphs above.

Appendix Table 2: Lall (2000) Technology Classification

LALL TECHNOLOGY CLASSIFICATION	EXAMPLES
PRIMARY PRODUCTS (PP)	Fresh fruit, meat, rice, cocoa, tea, coffee, wood, coal, crude petroleum, gas
MANUFACTURED PRODUCTS	
<u>Resource-based manufactures</u>	
RB1: Agro/forest based products	Prepared meats/fruits, beverages, wood products, vegetable oils
RB2: Other resource-based products	Ore concentrates, petroleum/rubber products, cement, cut gems, glass
<u>Low-technology manufactures</u>	
LT1: 'Fashion cluster'	Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods
LT2: Other low-technology	Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products
<u>Medium-technology manufactures</u>	
MT1: Automotive products	Passenger vehicles and parts, commercial vehicles, motorcycles and parts
MT2: Process industries	Synthetic fibres, chemicals and paints, fertilisers, plastics, iron, pipes/tubes
MT3: Engineering industries	Engines, motors, industrial machinery, pumps, switchgear, ships, watches
<u>High-technology manufactures</u>	
HT1: Electronics and electrical products	Office/data processing/telecommunications equip, TVs, transistors, turbines, power-generating equipment
HT2: Other high-technology	Pharmaceuticals, aerospace, optical/measuring instruments, cameras
OTHER TRANSACTIONS	
Other	Electricity, cinema film, printed matter, 'special' transactions, gold, art, coins, pets

Source: Lall (2010)

Appendix Table 3: Variable Descriptions and Sources

Variable	Description	Source
Fixed capital per worker	The capital per worker variable is constructed using employment data and capital stock data (constant 2005 US dollars).	Penn World Table Version 8.1 (Feenstra et al., 2013):
Total factor productivity (TFP)	TFP is computed using current PPP \$US, capital stock, labour input data, and labour share of income data. See Feenstra et al., (2013) for more information	http://www.rug.nl/research/ggdc/data/pwt/pwt-8.1
Opportunity value index	Measure of how many different products are near a country's current set of productive capabilities.	The Economic Complexity Observatory (Simoes & Hidalgo, 2011):
Economic complexity index	Measures the distance between the productive capabilities embodied in a countries current export structure and the productive capabilities embodied in the products that it does not yet export.	
Total natural resources rents (% of GDP)	Total natural resource rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Bank Development Indicators: http://data.worldbank.org/data-catalog/world-development-indicators
Count of manufacturing product exports	Measure of the number of manufacturing products exported.	BACI International Trade Database at the product level http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=1

Appendix Table 4: Explaining Manufacturing Performance over the Period 1995 to 2013 – Hausmann et al. (2011) Atlas Variable Specification – fixed effects estimation

	Log of product count of TM exports
Log of fixed capital per worker	0.119*
	[0.063]
Total factor productivity	0.073
	[0.103]
Total natural resources rents (% of GDP)	0.002
	[0.002]
Economic complexity index	-0.029
	[0.066]
Opportunity value index	0.150***
	[0.034]
Constant	6.037***
	[0.719]
Observations	1,750
R-squared	0.312
Number of groups	104
Country FE	YES
Year FE	YES

Notes: 1. Robust standard errors in brackets. 2. *** p<0.01, ** p<0.05, * p<0.1 3. TM = Total manufacturing. Total manufacturing refers to the sum of resource-based manufactures and low-, medium-, and high-technology manufactures. 4. 'Total natural resource rents' is used a proxy for natural resource abundance in a country. 5. The 'total factor productivity', the variable used to control for technology, and is measured using current PPPs with USA=1.