# Manufacturing Technology Intensity, Employment, Wages and Capital Formation in Africa

**Richard E. Itaman and Oluwafemi E. Awopegba**

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**Manufacturing Technology Intensity, Employment, Wages and Capital Formation in Africa**

DSI/NRF SOUTH AFRICAN RESEARCH CHAIR IN INDUSTRIAL DEVELOPMENT

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## Abstract

Given the potential for inclusive growth in manufacturing, this paper examines the effect of manufacturing sub-sectors, categorised by technology intensity, on employment, wages, gross fixed capital formation and female manufacturing employment in African countries for the period 1980 to 2019. It differentiates manufacturing sub-sectors by their technology intensity following the International Standard Industrial Classification (ISIC) revision 3, and the technological classification adopted by UNIDO, categorised into low, medium-low, medium-high and high technology, and consists of 10, five and eight technological groups respectively. We employed cross-sectional panel estimations and found a decline in manufacturing employment as output increased. The decline increased between 1985 and 2015 and, more significantly, in the low technology-intensity manufacturing sub-sector, with the medium-tech sub-sectors becoming the main drivers of employment in manufacturing. There was a sharp decline in female employment in manufacturing as output increased, largely attributed to low-tech manufacturing sub-sectors. However, medium- and high-tech sub-sectors are better able to retain female labour as manufacturing output increases. Similar to the pattern in employment, there was a sharp decline in wages as manufacturing output increased, due primarily to a fall in wages in low-tech sub-sectors. In contrast, wages increased at an increasing rate with medium- and high-tech manufacturing output. We find that capital formation falls as manufacturing output increases, dominated by the fall in low-tech manufacturing capital, with the rise in capital largely driven by medium- and high-tech sub-sectors. These findings are relevant for policymakers for understanding which manufacturing sub-sectors better sustain employment, wages and capital formation, including female employment, in the drive for industrialisation in African countries.

**Keywords:** manufacturing, technology intensity, employment, female employment, wages, capital formation, structural change, Africa

**JEL codes:** F21, J21, J31, L16, O14, O55

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## 1. Introduction

The reallocation of economic activities from low-value to high-value productive sectors, also known as structural transformation, has long been considered the central driver of economic development. Specifically, the manufacturing sector has increasingly been recognised as the engine of growth, with the level of technology intensity understood to be the crucial determinant of economic development (Lall 2001). Yet the success of technology-enhanced production in delivering development differs by level of income (Rowthron and Coutts 2004; Rowthorn and Ramaswamy 1997). This makes African countries with low levels of income and high unemployment an interesting focus for understanding the effect of technology intensity on economic development. The importance of such research is reinforced by the industrialisation drive on the African continent, including the challenges faced in securing productive employment.

This paper examines the effect of different manufacturing sub-sectors on employment, wages and physical capital formation in Africa, including on female manufacturing employment. We employ cross-sectional panel estimations to analyse the effect of manufacturing sub-sectors classed by levels of technology intensity. Emphasis is placed on technology intensity and sub-sectoral heterogeneity as underpinning sectoral differences in successful industrialisation across countries and time, in line with the structuralist tradition. The differentiation of manufacturing sub-sectors by their technology intensity follows the International Standard Industrial Classification (ISIC) revision 3, and the technological classification adopted by the United Nations Industrial Development Organization (UNIDO). These are categorised into low, medium-low and medium-high, and high technology, and consist of 10, five and eight technological groups respectively.

The choice of variables for measuring the effect of manufacturing is motivated by the growing literature on the importance of demand growth as a precondition for structural change (Chang and Andreoni 2020; Itaman and Wolf 2021). Supporting the growth of demand for manufacturing output through an increase in employment and wages, capital formation and employment for vulnerable groups is an important dimension for sustaining manufacturing growth. Given the challenges women face in securing productive employment, we extend our analysis to this group. Such demand-side conditions are necessary for redistributing and enhancing the growth of the purchasing power of consumers.

The contribution of this paper is located in increasingly teasing out the role of manufacturing in stimulating domestic demand for development, building on the literature on the relationship between manufacturing income and employment (Felipe et al. 2014). In addition, analysis of the sub-sectoral contribution of manufacturing is considered to be relevant for understanding the role of manufacturing in the light of the recent emphasis on heterogeneity and technology intensity as underpinning differences in the success of industrialisation across countries and time (Tregenna and Andreoni 2020). While the literature shows that emerging structural change has led to productivity growth in Africa, a research gap remains in relation to the effect of different levels of manufacturing activities on demand conditions, characterised by wages, employment, capital formation, and increasing employment for

vulnerable groups such as women. We aim to bring these strands of the literature together. The findings in this paper aim to inform policymakers on the contribution of different manufacturing sub-sectors for successful industrialisation in African countries, thereby enhancing industrial policy effectiveness.

We proceed by reviewing some of the theoretical underpinnings of the role of manufacturing in development and the heterogeneity in manufacturing outcomes, linked to the technology intensity of manufacturing sub-sectors. This is followed by a discussion of the effect of different manufacturing sub-sectors on employment, wages, capital formation and female manufacturing employment in Africa. Next, we discuss the data for the study and empirical analysis, including our estimation results.

## 2. Manufacturing and Technology Intensity

There is much consensus on the role of manufacturing in economic growth and structural transformation in developing countries (Kaldor 1966). This is because manufacturing enhances the potential for technological spillover and enables backward linkages (Kaldor 1970; Szimai and Verspagen 2015), and expands dynamic increasing returns and collective capabilities (Hirschman 1992; Prebisch 1962; Weiss 1990). These would ultimately increase income and employment (Felipe et al. 2014), not least as manufacturing tends to absorb a large proportion of the labour force and is a safeguard for employment (Dasgupta and Singh 2006; Rodrik 2013).

In traditionally absorbing a large proportion of the labour force, manufacturing enables the growth of demand through distributional processes. Evidence shows that supporting the growth of demand for manufacturing output is necessary for sustaining structural transformation, especially in developing countries (Itaman and Wolf 2021). In turn, demand conditions created by employment in manufacturing and wages earned by workers – in addition to other macroeconomic conditions that increase effective demand – drive firms' investment behaviour towards learning for successful industrialisation. This makes it imperative that manufacturing sustains the purchasing power of workers and communities in order to successful drive structural transformation.

However, there has been a decline in manufacturing value added (MVA) and employment share in manufacturing since the 1980s, with global industrial production becoming concentrated in a few countries, as highlighted by the deindustrialisation literature (see Palma 2005; Rowthorn and Coutts 2004; Rowthorn and Ramaswamy 1997). Using 2005 international dollars at PPP, Tregenna (2016) finds the decline in manufacturing starts to set in at $16 582, and at a share of manufacturing in total employment of 14 percent. Developing countries have been worse hit, as their deindustrialisation is starting at much lower levels of income, as such inhibiting their potential to achieve structural transformation. These countries have experienced deindustrialisation at a much earlier stage, and at lower levels of income when compared to advanced capitalist economies. Disaggregating the manufacturing sector by technology intensity shows the heterogeneity of the decline across the manufacturing sub-sectors, with the advanced economies experiencing greater decline in employment in the low-technology-intensity sub-sectors (Rodrik 2016).

Therefore, the effectiveness of countries in stimulating and sustaining domestic demand rests on the level of technology intensity and upgrading of their manufacturing sector. Tregenna and Andreoni (2020) analyse the differences in deindustrialisation in the manufacturing sub-sectors to understand patterns of deindustrialisation and highlight the heterogeneity within manufacturing, underpinned by differences in technological intensity, speed of technological change, levels of scale efficiency and degress of tradability, which exist within the manufacturing sub-sectors. Their findings highlight the degree to which different manufacturing sub-sectors are able to leverage technology intensity for structural transformation. This point was emphasised earlier by Schumpeter (1947) and Rosenberg (1982) in the context of technological upgrading from low- to high-technology-intensity sectors for innovation and structural transformation.

The heterogeneity of manufacturing sub-sectors also implies heterogenous structures, interests and political economy, given that production activities, distribution, supply chains and the nature of accumulation in the sub-sectors would have unique processes and products, underpinned by different technological input and modes of production (Andreoni and Chang 2017). Heterogeneity further implies that some sub-sectors of manufacturing will be more suited to acquiring capability and enabling structural transformation, depending on the level of development. This resonates with the “industries without smokestack” argument, which underscores the need for manufacturing to emerge in sectors with high productivity, while acknowledging the unlikelihood of a resemblance between Africa’s industrialisation process and the experience of other late industrialisers, such as East Asia, where manufacturing emerged from areas of low productivity (Newfarmer et al. 2018).

However, the categorical boundaries within the manufacturing sub-sector are increasingly blurred due to the heterogeneity of manufacturing activities and their integration into and across sectors, not least when integrated with the services sector (Cramer and Tregenna 2020). These factors further add to the complexity of the political economy in these sectors, which need to be understood for successful structural transformation. Existing conflict within the structural interdependence of these manufacturing sub-sectors needs to be managed to sustain development and achieve technological upgrading (Andreoni and Chang 2019).

Given the high degree of heterogeneity in the industrialisation experience of countries and sectors, which is seen to depend on the level of technological input, Tregenna and Andreoni (2020) found that the greater the level of technological intensity of manufacturing, the less concave is the relationship between manufacturing and growth. That is to say that high technological intensity sustains a positive effect of manufacturing on growth. We add more layers to this analysis by examining how technology intensity, underpinned by the heterogeneity of the manufacturing sub-sectors, affects the relationship between manufacturing and wages, employment, capital formation and female manufacturing employment in Africa. Thus, we show how existing heterogenous structures in manufacturing sub-sectors shape the outcomes for demand across Africa.

## 2.1 Manufacturing and Technology Intensity in Africa

Africa's manufacturing experience differs across countries. According to an UNCTAD (2011) report, which characterised the industrialisation experience of countries according to technology intensity, the share of manufacturing in value added in Africa rose from a low of 6.3 percent in 1970 to a high of 15.3 percent by 1990, after which it experienced a steady decline in all sub-regions of the continent – to 12.8 percent in 2000 and 10.5 percent in 2008. The share of manufacturing in Africa's exports also declined, from 43 percent in 2000 to 39 percent in 2008. This decline was seen in Africa's contribution to global manufacturing – from 1.2 percent in 2000 to 1.1 percent by 2008.

Some level of structural transformation has been seen on the continent in the post-2000s, as there has been an increase in the share of medium- and high-technology activities in total MVA across the continent, from 25 percent in 2000 to 29 percent in 2009. The chemical industry component in medium- and high-technology manufactures makes up about a fifth of African MVA. African exports, however, are heavily concentrated in medium technology rather than in high technology.

Small-scale and low-value manufacturing, which characterises manufacturing in Africa, has been argued to be important for the development process, as long as modern technological techniques are adopted to meet the domestic demand and provide employment opportunities (Lewis 1979). But the emergent manufacturing output has been insufficient to sustain structural transformation, as the MVA has remained low even in regions that recorded an increase. Therefore, a major fallout of the industrialisation experience of African countries post-independence is the gap in building the technological capability of domestic firms to enhance the production of medium- and high-technology products (Oyelaran-Oyeyinka 2006). We show elsewhere that the distinct lower rate of decline in employment share in manufacturing relative to MVA in African countries is evidence of low technological upgrading on the continent, given that higher technology intensity would have resulted in higher levels of declining employment share (Itaman and Awopegba 2021).

## 2.2 Manufacturing and Employment in Africa

There is some consensus in the literature that the manufacturing sector has higher potential for creating employment relative to other sectors, such as agriculture and services. Evidence shows that manufacturing has typically delivered more productive employment across Africa, with more stable employment mostly concentrated in construction and in other high-technology-intensive sectors such as transport and communication (McKinsey 2012). Also, findings by Kruse et al. (2021) suggest that even "unregistered small manufacturing firms" in sub-Saharan African countries tend to absorb workers, especially domestic firms that supply the local consumers to meet the continent's rising demand. Their findings indicate the potential of certain types of manufacturing for employment in sub-Saharan Africa, not least manufacturing by small-scale firms.

However, the share of labour-intensive manufacturing in total employment in Africa declined from 23 percent in 2000 to 20 percent in 2009, due in large part to the decline in activities

such as textiles, which employed a significant workforce. Labour-intensive exports also declined from 25 percent in 2000 to 18 percent in 2008, causing a fall in Africa's share of global labour-intensive exports from 1.5 to 1.3 percent in the same period (UNCTAD 2011). Despite two decades of sustained growth in the post-2000 period, following a long period of stagnation, the level of unemployment in Africa has remained significantly high. This is attributed mainly to factors such as a rapidly growing population, with the youth population estimated to be around 60 percent of the total (AfDB et al. 2014). This explosion in population, coupled with the absence of sustained manufacturing in Africa, poses concerns for employment and structural transformation.

The more recent shift in the production structure of African countries to the non-tradeable services sector implies that the nature of employment is predominantly informal. The informal services sector provides a broad range of employment in repairs, personal services like hairdressing salons, food service vendors, and trading activities in the telecommunications sector, with a rise of mobile phone and top-up kiosks across the continent. These informal services dominate rural employment in Africa and are prominent in urban employment, as not enough formal jobs are created in manufacturing.

Some studies have tried to draw on the advantages of this dominant informal sector and have pointed out that employment creation in sub-Saharan African (SSA) countries hardly depends on regulating the informal sector, nor on employment growth associated with measures of labour regulation in the informal sector (Fox and Gaal 2008). Instead, factors such as the lack of infrastructure and limited access to credit are said to shape the unemployment situation in SSA, and should be seen as the fundamental problem. Also, the skills shortage is said to put a constraint on job creation and makes the SSA region uncompetitive in relation to other emerging economies.

Given that workers in informal employment are not registered and often have no formal protection, a large percentage of employment in Africa is precarious. The large informal sector on the continent suggests that Africa's unemployment lies not necessarily in the lack of jobs, but rather in the quality of jobs created. Cramer et al. (2020) use ILO data to show that employment protection legislation (EPL) is necessary for raising the levels of employment in Africa, and in fact is compatible with increasing the levels of total (and youth) employment. According to them, EPL has the potential to make employers more competitive by adopting more technology-intensive means of production. They highlight the scope for large-scale investments in those specific economic activities most likely to generate rapid increases in demand for wage labour – such as targeting public sector capital expenditure, and investment that increases rural wage employment and the supply of basic wage goods and exports. These are more likely to generate employment, instead of the often "knee-jerk responses" by policymakers, who prefer expenditure on training and the provision of microcredit for entrepreneurial ventures. In relation to employment in manufacturing, Cramer et al. (2020) show that, between 1995 and 2011, the number of workers increased significantly in sectors such as construction. Manufacturing elasticity outperformed other sectors of the economy in sub-Saharan Africa, while it remains below average in other emerging economies.

## 2.3 Female Manufacturing Employment in Africa

The literature has largely been silent on the relationship between manufacturing and growth in female employment, despite emphasis on the potential of inclusive growth in manufacturing. Such inclusiveness has simply ignored female manufacturing employment, which is fundamental to achieving inclusive development. A reason for the negligence of female manufacturing employment in the literature could be the social construct that locates women outside of the manufacturing sector, and instead in agriculture and services, which often make up the informal sectors in many developing countries.

Remarkably, while the services sector employs more labour in medium- and high-tech services in general, women are employed mainly in lower paid and lower skilled labour-intensive jobs such as food and beverages, textile and apparel (United Nations Economic and Social Council [ECOSOC] 2016). The proportion of women in the manufacturing sector declined significantly, from 50 to 38 percent, from 1991 to 2014 (UNIDO 2016). In 2015, however, female employment in manufacturing was only slightly lower than that of males in low-income and middle-income countries, but significantly lower in high-income countries (ILO 2016).

## 2.4 Manufacturing and Wages in Africa

Wage differences can be observed across African countries, including relative costs of living, and not least between urban and rural areas. An obvious effect of this wage difference is rural-urban migration, driven by differences in wages and other labour market conditions (Harris and Todaro 1970). This migration is widespread across African countries, as workers increasingly seek better wages and working conditions. Szirmai et al. (2013) found that Africa's employment in general does not provide sufficient wages to enable workers and their dependants a level of consumption above the poverty line, along with a stable income and decent working conditions to overcome precarity. They argue that Africa's employment has also not been productive, but is characterised by low labour productivity levels and low productivity growth, low employment-to-population rates, and a high level of vulnerability amongst the employed who are living below the poverty line.

Given that low wages supposedly make production more competitive and increase manufacturing exports, Africa's increasing decline in manufacturing is more largely explained by the globalisation of production networks, including the requisite domestic investment in the manufacturing sector, as pointed out by Cramer et al. (2020). We examine wage growth in the manufacturing sub-sectors below.

## 2.5 Manufacturing and Capital Formation in Africa

The literature on capital formation in Africa is hinged on two factors. First, a declining foreign direct investment (FDI) inflow into the continent, or declining net inflows due to a high capital repatriation rate. Second, a low level of domestic investment due to a low savings rate, which allegedly is caused by low per capita incomes, low exports in output ratios, high and variable

interest rates, low interest rates, poor financial intermediation, relatively high aid flows and high birth rates (see United Nations [UN] 1995).

However, following the structural adjustment programme (SAP) of the 1980s, which promoted the withdrawal of government funding and interventionist policies for industrialisation, African manufacturing was to depend heavily on foreign capital mobilisation. The result was the weakening of the emerging domestic manufacturing base, despite the potential of technological upgrading in some sectors, as observed in countries such as Mozambique, Ghana, Nigeria and Zambia (Lall 2005).

As such, the size of manufacturing firms in Africa was a major obstacle to capital formation in the sector. Most manufacturing firms were small or micro-enterprises, operating alongside a few large-scale firms owned by foreigners or the State, with a large degree of concentration but little interaction and learning. Also, many of these manufacturing firms were located around raw material and the extractive sectors, and most likely without the level of formality to attract large capital. Low capital attraction, in turn, constrains investment in technological infrastructure, reinforcing the weak technological capability on the continent (Lall 2005).

There has been a rise in large domestic manufacturing firms in Africa in the post-2000 period, located mainly in low-value manufactured consumer goods. However, these firms have remained constrained by insufficient financing for long-term investment in manufacturing by domestic banks and volatile capital markets, whose preference is the higher-return services and extractive sectors at the expense of manufacturing. As such, emerging domestic manufacturing firms in Africa, organised as diversified business groups (DBGs), have been seen to embark on productive investments through high levels of physical capital accumulation – property, plant and equipment – due, in part, to their internal financing structure within a network of firms cutting across multiple sectors, and connected formally through equity or informally through kinfolk ties. This is incentivised largely by the anticipation of increasing demand for low-value manufactured consumer goods across the continent (Itaman and Wolf 2022). However, given the size constraint raised above for most manufacturing firms across Africa, capital formation remains a challenge.

We empirically test the level of manufacturing employment, including female manufacturing employment, wages and capital formation in Africa across manufacturing sub-sectors, differentiated by their levels of technological intensity, in the section that follows.

# 3. Methodology

## 3.1 Empirical Strategy

The empirical strategy employed in this study is on two levels: aggregate and sectoral analyses. The aggregate analysis explores the relationship between the share of manufacturing employment and gross domestic product (GDP) per capita and manufacturing output, whereas the sectoral analysis examines the relationship between employment, wages and capital formation and manufacturing output across technological intensities of

manufacturing for a set of African countries. The manufacturing sector is disaggregated into three levels of technological intensity – low, medium and high. The expected graphically non-linear relationship between growth and manufacturing employment is explored. We begin with a simple OLS regression model (with robust standard errors) that includes both GDP per capita and its squared term (in natural logs), following the approach used by Tregenna and Andreoni (2020). Here, the manufacturing output and its square term are regressed on each disaggregated element of manufacturing employment based on its technological grouping.

We add another layer to the analysis by comparing the relationship between manufacturing employment share and GDP per capita to that of manufacturing employment share and manufacturing output. This comparison is necessary so as to examine, in particular, the effect of an expansion of the manufacturing sector on the general employment level of the sector. In addition, the analysis is extended to explore how varying levels of manufacturing output affect female manufacturing employment. Moreover, the temporal shifts in the curve are investigated to account for periods of significant structural changes on the continent (i.e. two periods covering the structural adjustment era of the 1980s and 1990s, and two periods in the post-2000s).

## 3.2 Data

Data on wages and employment is sourced from the WDI and ILO respectively. For the aggregate analysis, total and manufacturing employment data is sourced from the ILOSTAT database. Data on GDP and population is obtained from the United Nations Main National Accounts database (UNMNA), while data on manufacturing output is taken from the UNIDO INDSTAT2 database.

The data on employment comprises 46 African countries for the period 2009 to 2020. However, there are limitations to the employment in manufacturing data, as only four of the 46 countries (Egypt, Mauritius, South Africa and Tunisia) have complete observations for the period. The majority of the countries have data for only one period. Nevertheless, data on GDP per capita consists of all 54 African countries (according to the UNMNA classification), in the time period spanning 1970 to 2019. Manufacturing output data is made up of 33 countries, from the year 1963 to 2019. Given the employment data constraint, we limit the aggregate analysis to an 11-year period from 2009 to 2019. This gives a sample of 46 countries (see Table A1).

For the sectoral analysis, we take advantage of the comprehensive data on manufacturing provided by the United Nations Industrial Development Organisation (UNIDO) INDSTAT2 database. The sub-sectoral data comprises 23 manufacturing sub-sectors, as shown in Table 1, and is grouped per technological intensity according to the UNIDO classification. The database includes information on, among others, each sub-sector's total employment, female employment, wages and capital, which permits this study to investigate their relationship with manufacturing output. For the purpose of the study, we limit the sectoral analysis to the time period 1980 to 2019.

**Table 1: Manufacturing Industries at the Two-digit Level of ISIC Rev 4**

| Technology Intensity | Sub-sector | ISIC |
|---|---|---|
| Low technology | Wood products (excl. furniture) | 20 |
| | Wearing apparel, fur | 18 |
| | Tobacco products | 16 |
| | Textiles | 17 |
| | Recycling | 37 |
| | Printing and publishing | 22 |
| | Paper and paper products | 21 |
| | Leather, leather products and footwear | 18 |
| | Furniture; manufacturing n.e.c. | 36 |
| | Food and beverages | 15 |
| Medium technology | Fabricated metal products | 28 |
| | Coke, refined petroleum products, nuclear fuel | 23 |
| | Rubber and plastics products | 25 |
| | Non-metallic mineral products | 26 |
| | Basic metals | 27 |
| High technology | Radio, television and communication equipment | 31 |
| | Other transport equipment | 34 |
| | Office, accounting and computing machinery | 29 |
| | Motor vehicles, trailers, semi-trailers | 34 |
| | Medical, precision and optical instruments | 33 |
| | Machinery and equipment n.e.c. | 29 |
| | Electrical machinery and apparatus | 31 |
| | Chemicals and chemical products | 24 |

# 4. Empirical Results

## 4.1 Descriptive Analysis

Table 2 presents the summary statistics of the main variables used in the study. Over time, manufacturing share of employment fell at the aggregate level. However, at the sub-sectoral level, the share of employment declined, but we observe a rise in the employment shares for medium- and high-technology sectors by 2015. For brevity, the summary statistics for the sub-sectoral variables, female employment, wages and capital, are placed in Table A2 in the appendix.

**Table 2: Descriptive Statistics**

| | Year | Obs | Mean | Std dev. | Min | Max |
|---|---|---|---|---|---|---|
| Aggregate analysis | | | | | | |
| Manufacturing share of employment | 2009 | 176 | 10.69 | 5.48 | 2.09 | 18.18 |
| | 2019 | 201 | 9.58 | 2.94 | 5.75 | 27.92 |
| GDP per capita | 2009 | 747 | 2 848.47 | 4 253.84 | 105.20 | 24 363.81 |
| | 2019 | 747 | 2 660.46 | 2 402.42 | 103.95 | 16 710.24 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Manufacturing output | 2009 | 374 | 18 648.78 | 39 192.84 | 40.86 | 164 978.00 |
| | 2019 | 132 | 43 018.44 | 56 333.17 | 3 099.99 | 164 850.00 |
| Within-sectoral analysis | | | | | | |
| Manufacturing output | 1985 | 330 | 6 524.42 | 9 788.64 | 153.90 | 35 449.31 |
| | 1995 | 462 | 8 719.49 | 17 968.67 | 31.19 | 82 975.47 |
| | 2005 | 352 | 16 384.42 | 38 704.24 | 29.20 | 161 946.00 |
| | 2015 | 418 | 21 947.36 | 35 956.54 | 213.92 | 151 356.00 |
| Low-tech share of employment | 1985 | 119 | 10.38 | 12.95 | 0.00 | 65.64 |
| | 1995 | 165 | 9.24 | 12.68 | 0.00 | 64.53 |
| | 2005 | 121 | 8.18 | 11.36 | 0.00 | 56.85 |
| | 2015 | 151 | 7.98 | 11.37 | 0.00 | 58.60 |
| Medium-tech share of employment | 1985 | 70 | 4.03 | 4.96 | 0.00 | 33.20 |
| | 1995 | 96 | 3.93 | 4.76 | 0.00 | 33.82 |
| | 2005 | 61 | 3.86 | 2.97 | 0.00 | 14.77 |
| | 2015 | 79 | 4.59 | 5.19 | 0.00 | 27.04 |
| High-tech share of employment | 1985 | 50 | 1.78 | 2.07 | 0.00 | 9.51 |
| | 1995 | 80 | 1.30 | 1.64 | 0.00 | 7.47 |
| | 2005 | 63 | 1.07 | 1.73 | 0.00 | 9.18 |
| | 2015 | 79 | 1.71 | 2.61 | 0.00 | 12.04 |

Source: Authors' compilation

## 4.2 Aggregate Analysis

The estimations for manufacturing as a share of total employment over GDP per capita and manufacturing output are shown in Figure 1. The curves do not yield an inverted U shape with turning points, as we expected. This could imply that the level of income or output at which the share of employment stops rising and begins to decline in Africa has not been reached. Compared to that of the regression on income, the estimation of output in manufacturing depicts a deeper slope in the curve, yet not at the point of inflection for an inverted U shape.

Adding a time dimension to the regression, leads to the inverted U-shaped curve, but in different periods, as shown in Figure 2. This result is possible due to the small and changing sample of countries in each time regression.

**Figure 1: Estimation of Manufacturing Share of Total Employment over GDP per Capita and Manufacturing Output**

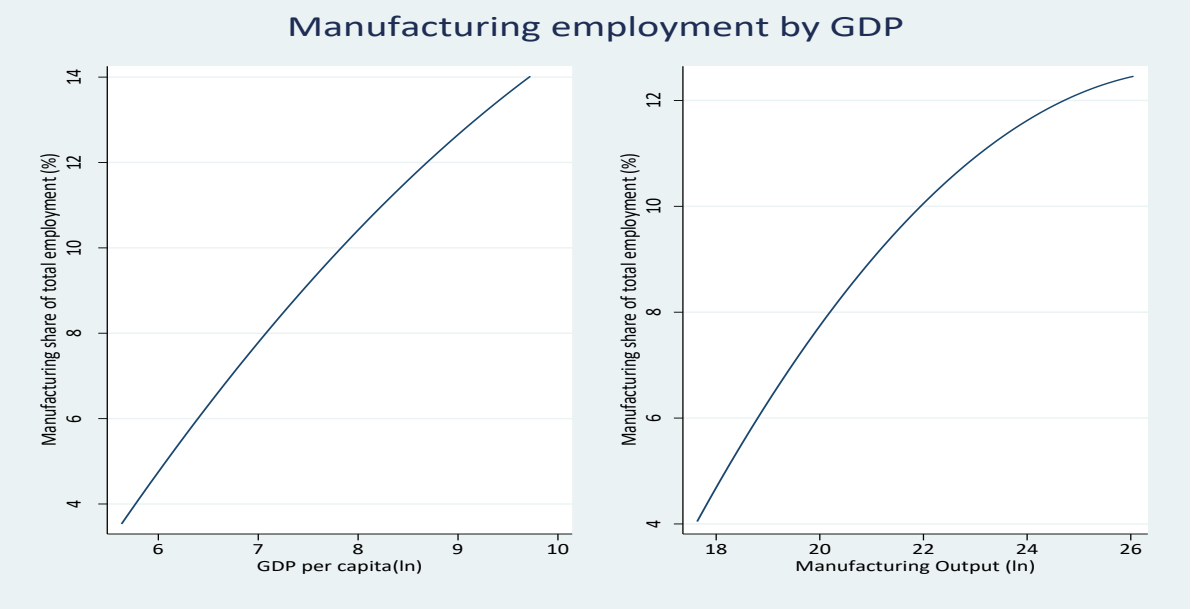
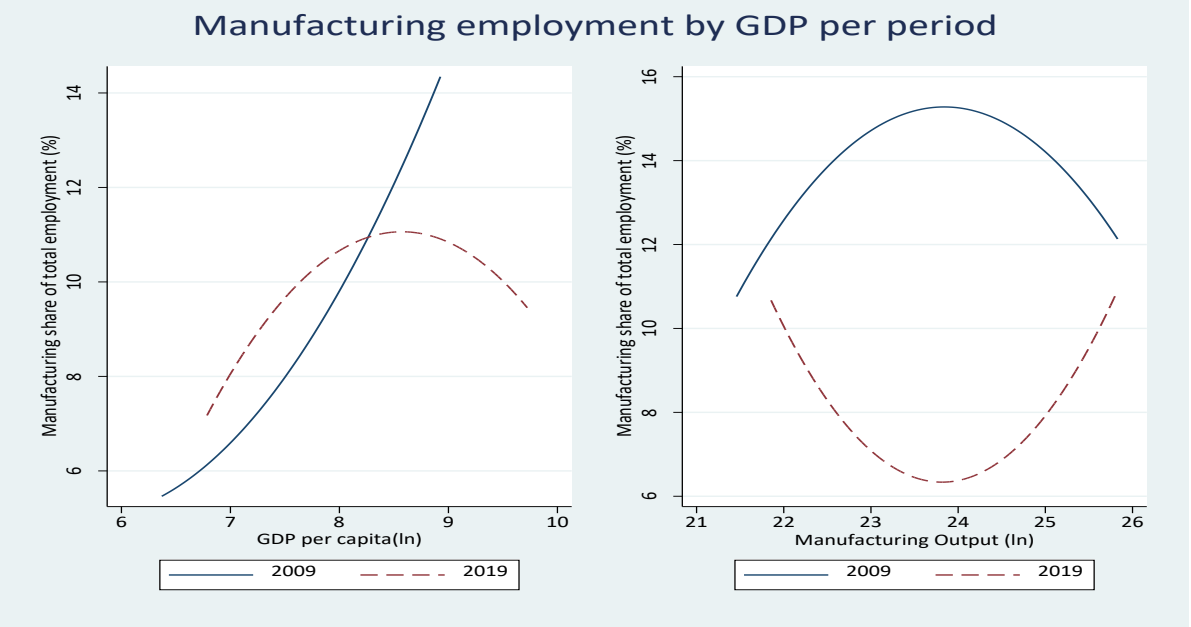



**Figure 2: Estimation of Manufacturing Share of Total Employment over GDP per Capita and Manufacturing Output for Different Time Periods**




## 4.3 Within-sector Analysis

We examined the relationship between employment among our variables of interest and manufacturing output, going beyond the aggregate level to explore the patterns at the sectoral level. First, we analysed the relationship over time, and second we explored the pattern for a specified time period and across technological intensities. We expected the trajectories in the relationships to vary over time and differ by technological intensity. The non-overlapping 10-year periods capture changes in the configurations in terms of manufacturing sector output in Africa over time. For example, the periods between 1985 and

1995 capture the incidence of structural adjustment policies across African countries, for which manufacturing VA declined increasingly.

## 4.4 Manufacturing Employment

Figure 3 depicts the decline in employment in manufacturing as the output of the sector increased. This decline is worse in the period 1985 to 2015, while more pronounced in the low-technology-intensity sub-sector of the manufacturing sector. For the medium- and high-tech sub-sectors, the reverse is the case, as the curve slopes upwards. Moreover, the curve of the medium-tech sub-sector is higher than that of the high-tech sub-sector, while also intersecting with that of the low-tech sub-sector. This indicates that the medium-tech sub-sector is becoming the main driver of employment in manufacturing in Africa.

The pattern of employment in manufacturing is also examined over time by technology intensity in Figure 4. Although the decline in employment in the low-tech sub-sector persists, the curve flattens. By 1985, employment in mid-tech manufacturing was on the rise as output in manufacturing increased. But, over the 40-year period, employment in the mid-tech manufacturing curve became increasingly convex and downward sloping. Moreover, the employment gap between medium- and high-tech sub-sectors widened by 2015.

We further explored the pattern of change by gender, and find that female employment in manufacturing experienced a sharp decline as output increased in the sector, as shown in Figure 5. This sharp decline is attributed largely to the low-tech manufacturing sub-sectors. Although female employment in manufacturing has declined, the shape of the curve is convex, demonstrating that higher-tech sub-sectors are better able to retain female labour as manufacturing output expands.

Focusing the analysis on female employment in manufacturing, the curve as of 1985 displays a U shape, as shown in Figure 6, indicating an initial drop in female labour participation, and then a rise in the same as output in manufacturing increased. From the 1990s, female employment declined, with the biggest effect witnessed in the medium- and low-tech sub-sectors. By 2005, high-tech sectors seemed to hold the promise of offsetting the overall decline in female employment in manufacturing. However, all the curves across all technological intensities sloped downwards by 2015.

**Figure 3: Estimation of Manufacturing Employment and Output, Disaggregated by Manufacturing Sub-sectors, and Over Time**

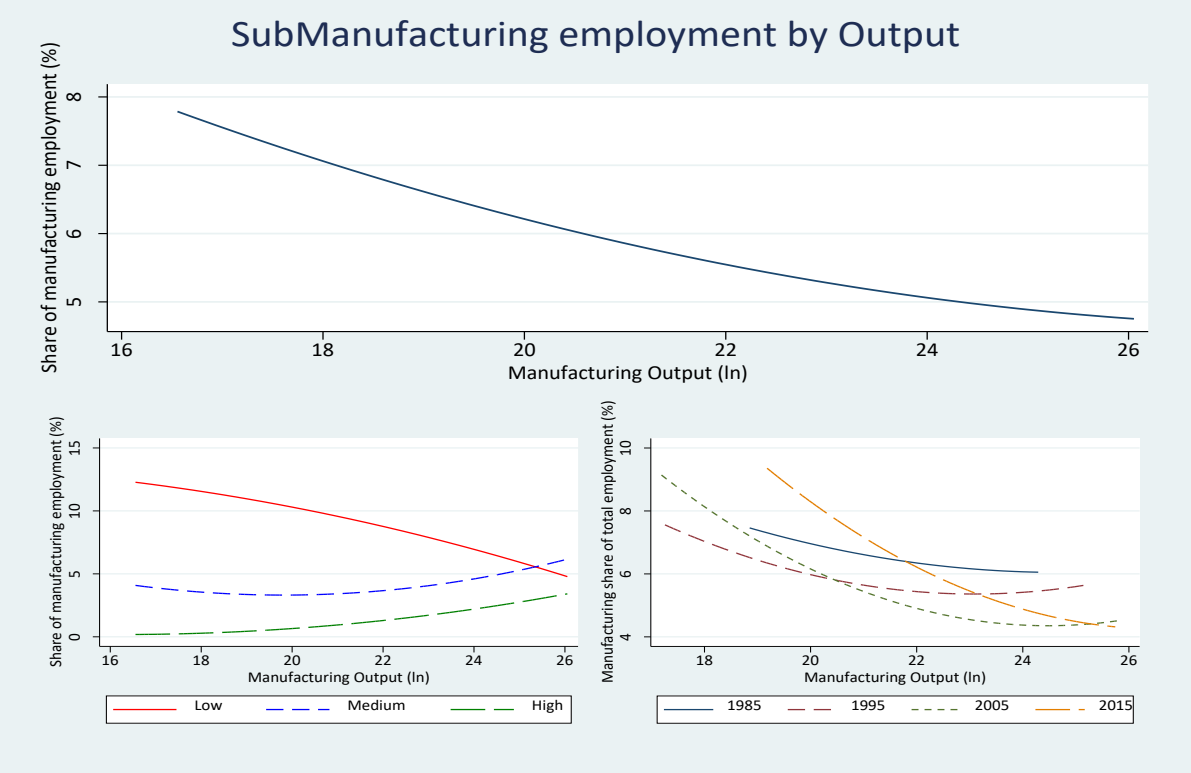



**Figure 4: Estimation of Manufacturing Employment and Output, Disaggregated by Sub-sectors and Shifts over Specific Time Periods**

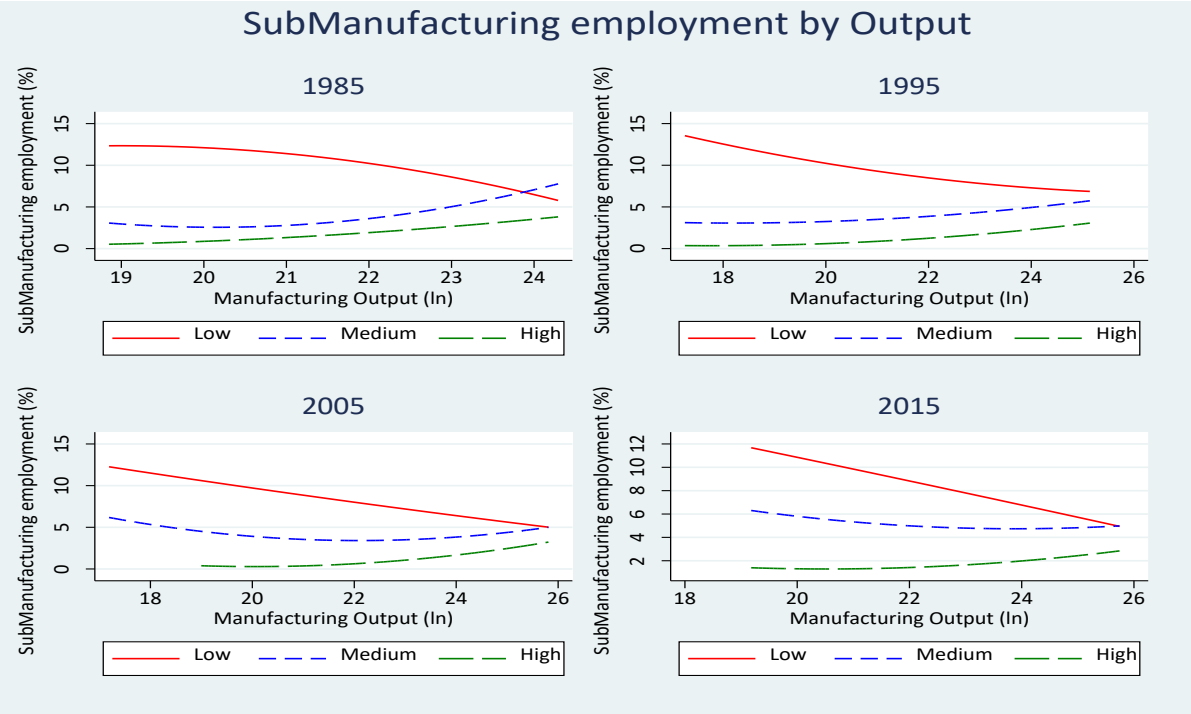


**Figure 5: Estimation of Female Manufacturing Employment and Output, Disaggregated by Manufacturing Sub-sectors, and Over Time**

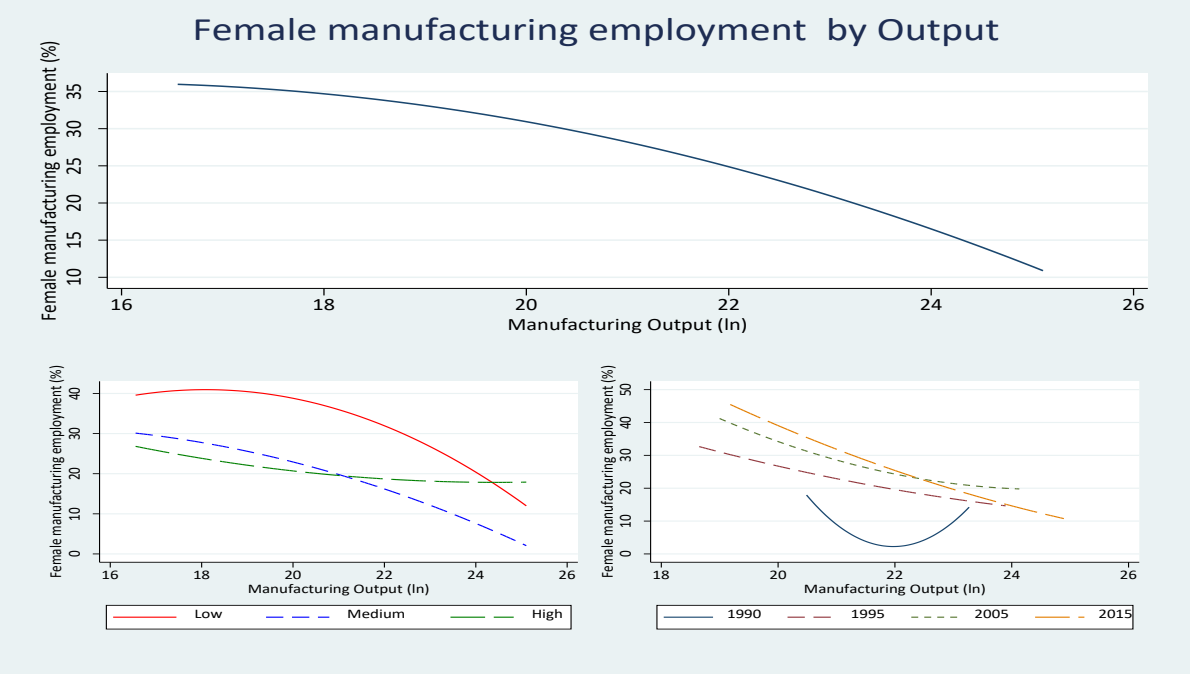
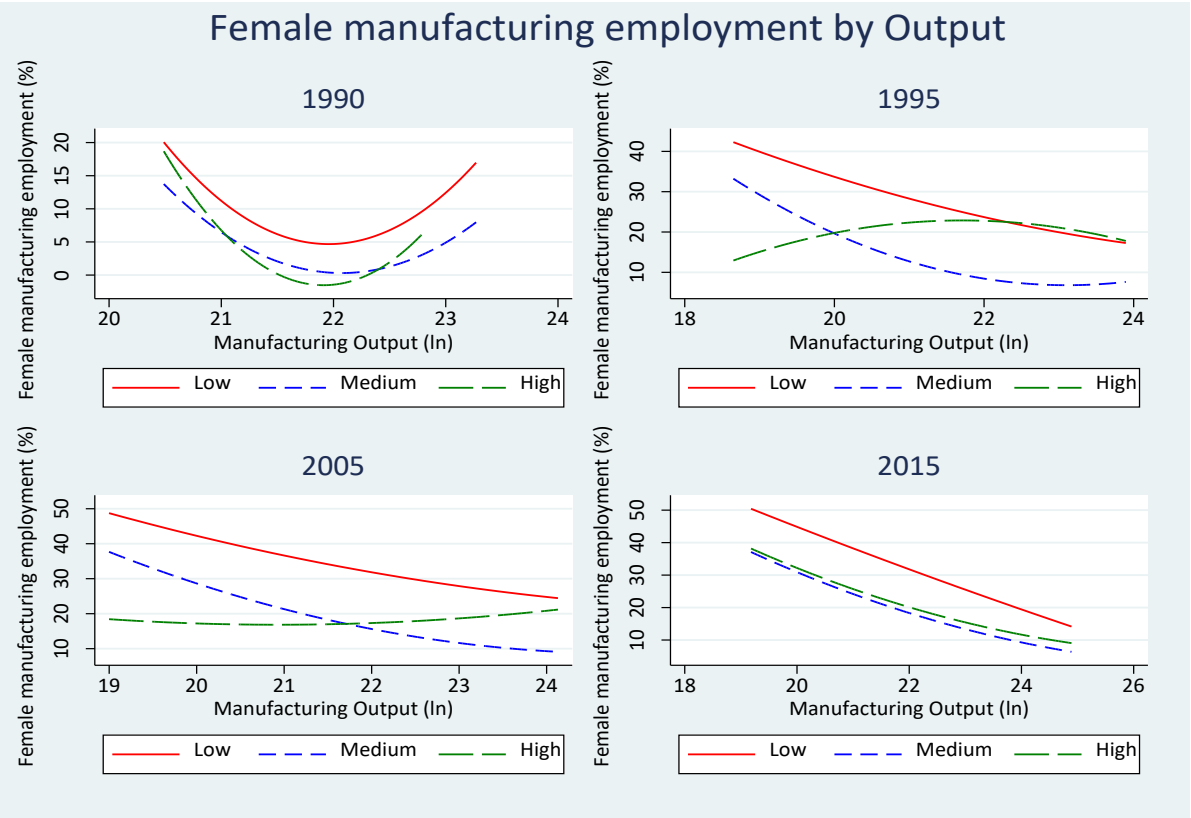



**Figure 6: Estimation of Female Manufacturing Employment and Output, Disaggregated by Sub-sectors, and Shifts over Specific Time Periods**



## 4.5 Wages

In addition, we consider the dynamics of manufacturing sub-sectors by wages as illustrated in Figure 7. Similar to the pattern observed in female employment, there was a sharp (concave) decline in wages as output increased. However, this is exceptional due to a fall in wages in low-tech sub-sectors. In contrast, the medium-tech curve is convex, indicating that wages increased at an increasing rate with manufacturing output. Likewise, wages in high-tech manufacturing increased, but with a less steep convex curve.

Figure 8 depicts these changes by period, demonstrating that the snapshot evidence is consistent for each technology category over time. For most of the period, the low-tech curves drop at an increasing rate. On the other hand, the low- and medium-tech curves rise, although the gap between both curves increases over time. Notably, the high-tech sub-sector curve becomes more convex over time.

**Figure 7: Estimating Manufacturing Wages and Output, Disaggregated by Sub-sectors Over Time**

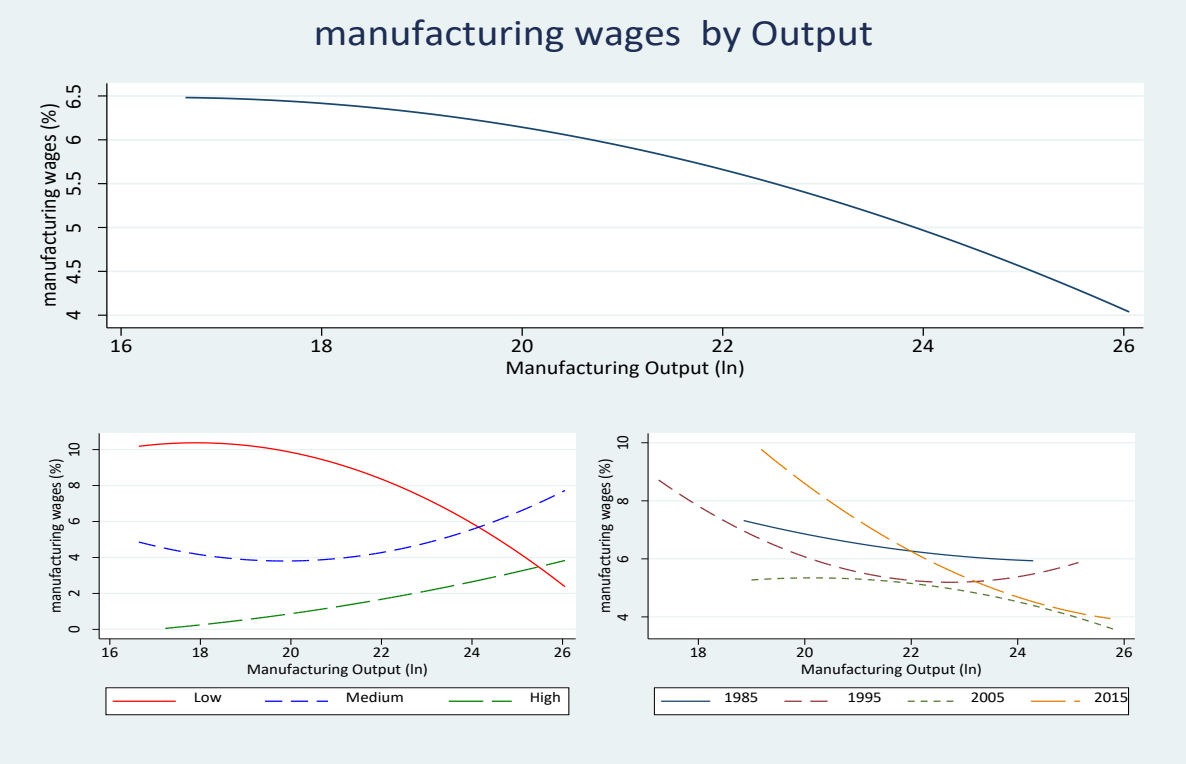
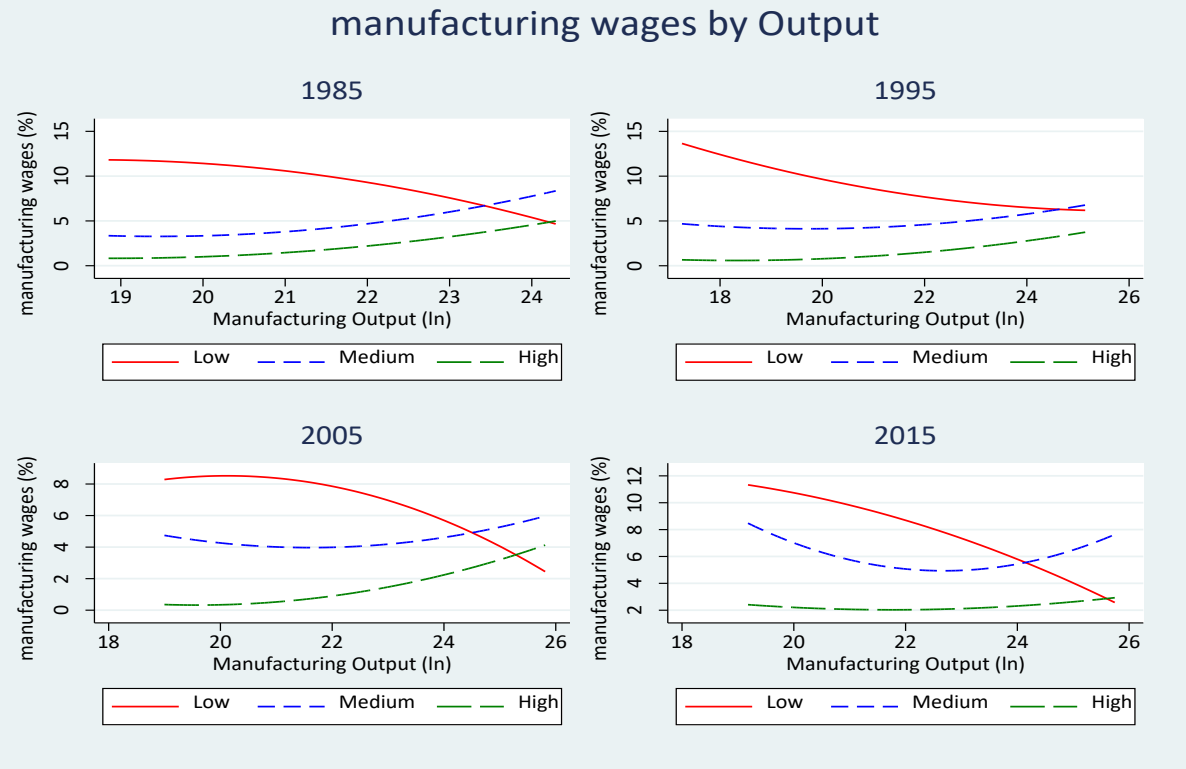


**Figure 8: Estimating Manufacturing Wages and Output, Disaggregated by Sub-sectors, and Shifts over Specific Time Periods**




## 4.6 Capital Formation (Gross Fixed Capital Formation)

Next, the changes in the pattern of manufacturing sub-sectors are explored by investment in fixed capital, as shown in Figure 9. We see that manufacturing capital falls as manufacturing output rises, and then increases slightly. Low-tech sub-sector manufacturing dominates the fall in manufacturing capital, while the rise in capital is largely influenced by the medium- and high-tech sub-sectors. The trend over time shows that the curve changes sharply from concave to convex, indicating an initial decline and then a rise in gross fixed capital formation.

Figure 10 portrays the pattern of capital in manufacturing over time by technology intensity. The low-tech sub-sector show a consistent decline in the accumulation of capital over time. In contrast, the medium-tech sub-sector indicate a fairly flat curve, while the high-tech sub-sector shows decreasing and then increasing capital accumulation, as reflected in the convex curves.

**Figure 9: Estimating Manufacturing Capital Formation and Output, Disaggregated by Sub-sectors Over Time**

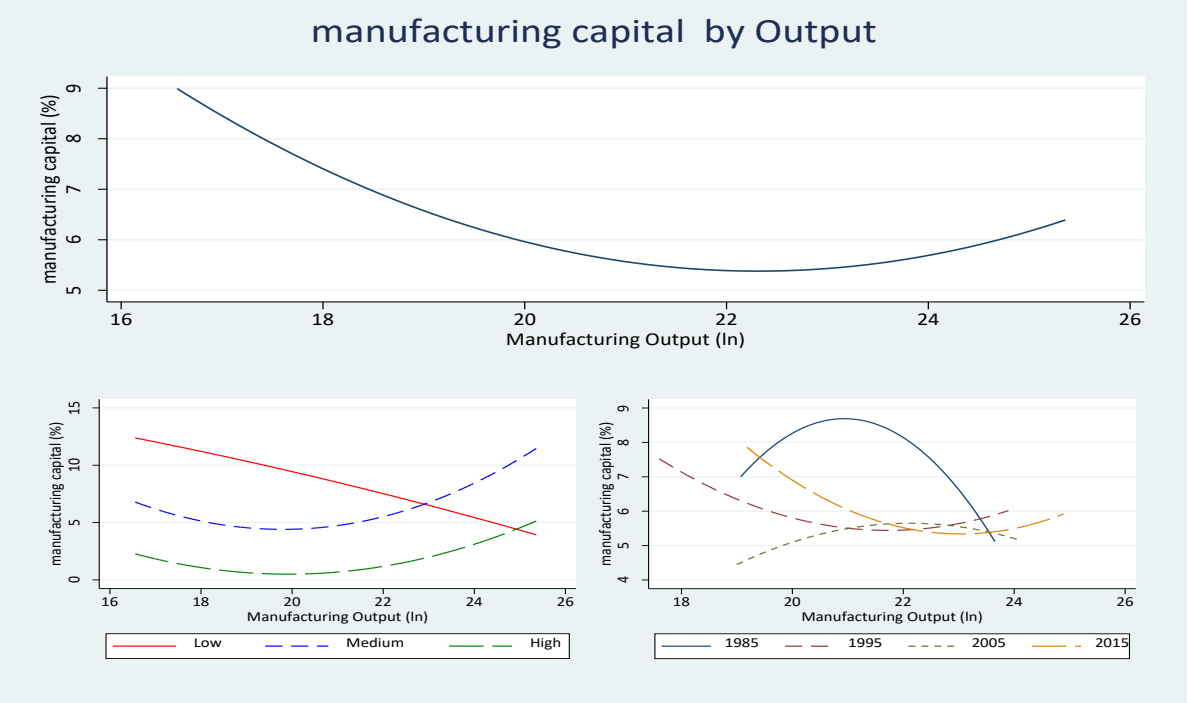
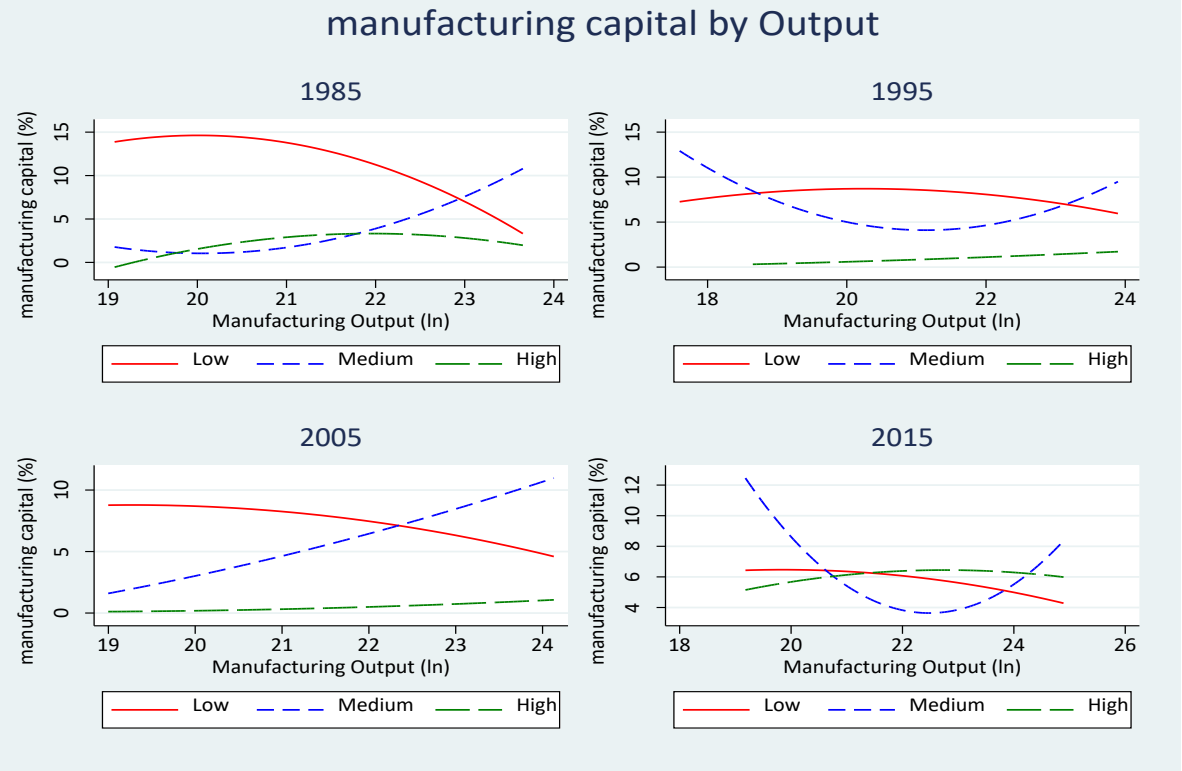



**Figure 10: Estimating Manufacturing Capital Formation and Output, Disaggregated by Sub-sectors, and Shifts over Specific Time Periods**



## 5. Concluding Remarks

In line with the literature that shows a declining level of manufacturing at different levels of income per capita, our estimations show declining levels of employment, wages, capital formation and women's employment, primarily in the low-technology manufacturing sub-sectors. This suggest that, while the low-tech manufacturing sub-sector may have kick-started output growth in the manufacturing sector, the absence of technology upgrading in the sub-sector has ensured that structural transformation is not sustained. However, opportunity abounds in the medium-technology sub-sectors, as employment, wages and capital show potential to rise. Our findings further suggest that there may even be some potential for female employment in the high-technology manufacturing sub-sector, given the transitory indication around 2005, before the decline in manufacturing across all sub-sectors of manufacturing.

As in high-income economies, which are experiencing a greater decline in employment in the low-technology-intensity sub-sectors (Rodrik 2016), African countries show similar trends to a greater degree, with more dire consequences for development outcomes. This reinforces the argument for structural transformation and the need for manufacturing growth, not least for technological upgrading as a means of sustainable development. High technological intensity is seen to sustain a positive effect of manufacturing on growth and employment, even with the share of employment relatively steady in the medium-technology sub-sector, as in Tregenna and Andreoni (2020). While there may still be some room for low-technology manufacturing to revamp growth in African countries by reviving production in some low-value consumer goods, it is the medium-technology manufacturing sub-sector that holds the most potential for a positive effect on employment, wages and capital formation.

As such, it is necessary to increasingly upgrade production towards achieving some level of medium-technology manufacturing in order to sustain growth and realise the needed structural transformation across the continent. This would include light manufacturing activities and processing commodities into finished products that fall under the medium-tech sector. Medium-technology manufacturing sub-sectors include some level of manufacturing at the higher end of the technological ladder, such as fabricating metal into finished products like sewing machines and parts for assembly in plants, and refining minerals into finished products and into non-metallic products of minerals. The skills and training required for these sets of activities already exists in Africa, and vocational training could be offered to expand their capacity.

To drive employment, African countries therefore need to focus industrial policy initiatives on upgrading to medium-tech sectors. This is also key for achieving and sustaining higher wages for labour, including guaranteeing economic equality for marginalised groups. In addition, targeting medium-tech sub-sectors has the potential to address the problem of insufficient capital by stimulating physical capital accumulation in African countries, which potentially can feed back into higher levels of technological capability. Thus, we show the level of upgrading needed to sustain structural transformation in Africa, while emphasising

the need for country-specific industrial policies to meet their structural transformation objectives.

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# Appendices

## Table A1: Sample of Countries

| Country | |
|---|---|
| Algeria*(**) | Liberia* |
| Angola*(**) | Libya*(**) |
| Benin* | Madagascar*(**) |
| Botswana*(**) | Malawi(**) |
| Burkina Faso* | Mali* |
| Burundi*(**) | Mauritania* |
| Cabo Verde(**) | Mauritius*(**) |
| Cameroon*(**) | Morocco*(**) |
| Cape Verde* | Mozambique*(**) |
| Chad* | Namibia*(**) |
| Comoros* | Niger*(**) |
| Congo*(**) | Nigeria*(**) |
| Côte d'Ivoire*(**) | Rwanda*(**) |
| D.R. of the Congo* | Sao Tome and Principe* |
| Djibouti* | Senegal*(**) |
| Egypt*(**) | Seychelles* |
| Eritrea(**) | Sierra Leone* |
| Eswatini*(**) | South Africa*(**) |
| Ethiopia*(**) | Sudan* |
| Gabon(**) | Togo* |
| Gambia*(**) | Tunisia*(**) |
| Ghana*(**) | Uganda*(**) |
| Guinea-Bissau* | United Republic of Tanzania*(**) |
| Kenya*(**) | Zambia*(**) |
| Lesotho* | Zimbabwe*(**) |

NB: *(**) denotes countries in aggregate (and sectoral) analysis

## Table A2: Summary Statistics for the Sub-sectoral Variables

| | Year | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|---|
| Within-sectoral Analysis | | | | | | |
| Low-tech share of wages | 1985 | 111 | 9.75 | 12.31 | 0.00 | 50.87 |
| | 1995 | 157 | 8.78 | 12.05 | 0.00 | 68.81 |
| | 2005 | 123 | 7.10 | 10.49 | 0.00 | 52.94 |
| | 2015 | 131 | 7.11 | 12.26 | 0.00 | 75.82 |
| Medium-tech share of wages | 1985 | 65 | 4.72 | 5.61 | 0.00 | 36.60 |
| | 1995 | 93 | 4.72 | 4.44 | 0.00 | 22.77 |
| | 2005 | 63 | 4.37 | 3.38 | 0.00 | 17.22 |
| | 2015 | 67 | 5.73 | 7.60 | 0.00 | 49.62 |
| High-tech share of wages | 1985 | 46 | 2.14 | 2.47 | 0.00 | 9.20 |
| | 1995 | 73 | 1.58 | 2.05 | 0.00 | 9.19 |
| | 2005 | 68 | 1.45 | 2.30 | 0.00 | 11.35 |
| | 2015 | 68 | 2.31 | 3.96 | 0.00 | 25.96 |
| | | | | | | |
| Low-tech share of employment | 1985 | 119 | 10.38 | 12.95 | 0 | 65.64 |
| | 1995 | 165 | 9.24 | 12.68 | 0 | 64.53 |
| | 2005 | 121 | 8.18 | 11.37 | 0 | 56.86 |
| | 2015 | 151 | 7.98 | 11.37 | 0 | 58.60 |
| Medium-tech share of employment | 1985 | 70 | 4.03 | 4.96 | 0 | 33.20 |
| | 1995 | 96 | 3.93 | 4.76 | 0 | 33.82 |
| | 2005 | 61 | 3.86 | 2.97 | 0 | 14.77 |
| | 2015 | 79 | 4.60 | 5.19 | 0 | 27.04 |
| High-tech share of employment | 1985 | 50 | 1.78 | 2.07 | 0 | 9.51 |
| | 1995 | 80 | 1.30 | 1.64 | 0 | 7.47 |
| | 2005 | 63 | 1.07 | 1.73 | 0 | 9.18 |
| | 2015 | 79 | 1.71 | 2.61 | 0 | 12.04 |
| | | | | | | |
| Low-tech share of female employment | 1985 | 6 | 22.52 | 15.10 | 2.47 | 47.37 |
| | 1995 | 61 | 25.05 | 20.04 | 2.87 | 81.25 |
| | 2005 | 61 | 34.55 | 22.77 | 6.48 | 86.94 |
| | 2015 | 60 | 34.26 | 23.90 | 1.01 | 93.75 |
| Medium-tech share of female employment | 1985 | 3 | 7.10 | 3.48 | 3.13 | 9.60 |
| | 1995 | 32 | 13.50 | 12.59 | 2.43 | 70.37 |
| | 2005 | 31 | 19.56 | 15.31 | 0.00 | 69.00 |
| | 2015 | 30 | 17.39 | 14.31 | 1.95 | 50.93 |
| High-tech share of female employment | 1985 | 4 | 18.86 | 10.91 | 9.90 | 33.33 |
| | 1995 | 25 | 18.07 | 14.61 | 0.00 | 65.51 |
| | 2005 | 29 | 18.94 | 15.64 | 0.00 | 71.83 |
| | 2015 | 26 | 19.00 | 11.93 | 3.18 | 50.77 |
| | | | | | | |
| Low-tech share of capital | 1985 | 40 | 11.15 | 17.88 | -0.47 | 72.67 |
| | 1995 | 110 | 7.90 | 11.90 | -0.03 | 71.71 |
| | 2005 | 69 | 7.23 | 12.01 | 0.00 | 52.28 |
| | 2015 | 51 | 5.39 | 11.72 | -2.88 | 65.61 |
| Medium-tech share of capital | 1985 | 21 | 4.46 | 9.16 | 0.00 | 42.71 |
| | 1995 | 63 | 6.37 | 7.92 | -2.65 | 36.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2005 | 35 | 6.29 | 6.27 | 0.00 | 21.07 |
| | 2015 | 29 | 6.53 | 10.36 | -15.09 | 38.98 |
| High-tech share of capital | 1985 | 17 | 1.58 | 2.40 | 0.00 | 7.95 |
| | 1995 | 51 | 0.94 | 1.49 | -0.38 | 5.55 |
| | 2005 | 38 | 0.54 | 0.98 | 0.00 | 4.73 |
| | 2015 | 27 | 6.16 | 14.33 | -1.02 | 69.48 |

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