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DISCUSSION PAPER SERIES

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ABSTRACT

Africa's Industrialization Prospects: A Fresh Look

This paper identifies the determinants of industrialization in 18 African countries, 1965 to 2018, using various estimators and applying a battery of robustness checks. Industrialization in Africa is driven by historical legacies such as colonialism; geographical factors such as rainfall and distance from international markets; economic factors such competition from China, market size and urbanization; and technological factors such as digital technology adoption. An inverse U-shape relationship between industrialization and GDP per capita is consistent with (premature) de-industrialization. Technological change and adoption of digital technologies are found to have an ambiguous relationship with industrialisation in Africa. The establishment of the AfCFTA is timely, but its benefits will only be realised if countries also improve infrastructure to overcome the negative consequences of adverse geography, improve trade facilitation to exploit learning-by-exporting from intra-African trade, and facilitate urbanization.

JEL Classification: O47, O33, J24, E21, E25

Keywords: industrialization, development, employment, technology, trade, Africa

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1 Introduction

The industrial revolutions that have transformed human civilization since the late 17th century have sparked an abiding interest in the long-run mechanics and dynamics of economic development, see e.g. Frey (2019), Landes (1999), Marsh (2012), or Mokyr (2017). From the huge literature that this has spawned, there is broad agreement that economic development is a process of structural change, wherein the industrial sector plays an important role: in virtually all development trajectories, industrialization has been a key driver of structural change (Bénétrix et al., 2015; McMillan and Zeufack, 2022; Szirmai et al., 2013).

The economies of Sub-Saharan Africa (SSA) although characterised by substantial heterogeneity, are largely rural, farming-based, and has remained on the margins of global industry (Andreoni and Tregenna, 2020; McMillan and Rodrik, 2011). They have yet to fully reap the benefits from the earlier industrial revolution at a time when the outlines of a sixth industrial revolution are already being noted (Groumpos, 2021; Silva and Serio, 2016). Having the world's fastest growing population, heading towards 3.8 billion people by the end of the century (de la Croix and Gobbi, 2022), the need for African economies to industrialize, and within the parameters of planetary boundaries, is imperative. The middle-income trap seemingly more and more binding (Andreoni and Tregenna, 2020), fewer non-Western countries making it to developed status (Wade, 2016) and global growth is in long-term decline (Philippon, 2022; Naudé, 2022). Accordingly, the topic of strategic industrial policy ought to be prioritised on the African development agenda. This paper contributes towards a strong frame of reference for the question of how to industrialize in Africa, by providing empirical estimates of the long-and-short run determinants of industrialization in Africa.

Surprisingly, the question of what drives industrialization in Africa has been somewhat neglected. Most studies into industrialization on the continent has dealt with the question whether or not it is de-industrializing (Nguimkeu and Zeufack, 2019), and if so if this is premature (Rodrik, 2016); it has also dealt with the question whether industrialization is still an engine of productive structural transformation (McMillan and Zeufack, 2022), and if not, whether other sectors can fulfill the role manufacturing has played in the past in other regions (Gollin, 2018).

Two recent studies that did attempt to answer the question of what drives industrialization in Africa, by Mensah (2020) and Tregenna et al. (2021) have therefore made significant additions to the literature. However, they have left important gaps. Mensah (2020) for instance derive his parsimonious choice of possible determinants[1] largely from the study by Kollmeyer (2009), which had dealt with the determinants of industrialization in advanced economies. He therefore does not consider Africa-specific factors, such as its unique history and geography. Tregenna et al. (2021), whilst considering a longer list of possible determinants, do not focus only on Africa, but on a sample of 99 countries, and over a rather short period, 1991 to 2014. Moreover, they failed to identify consistent and robust determinants for their total sample, concluding that more dis-aggregated analyses are needed, such as focusing on particular regions and countries. Of course, the rationale for focusing on particular regions and countries, such as Africa, is to be able to consider the possible unique drivers in those regions and countries - such as history and geography amongst others.

In this paper our contribution is to provide a fresh look into Africa's industrialization prospects by re-investigate the determinants of African industrialization, taking into particular consideration the African context. Given that industrialization is a process of structural transformation that defines the notion of economic development, we make use of the rich literature on the determinants of economic development in Africa to identify drivers of industrialization. We do this in section 2, where we identify historical legacies, geography, institutions, policies, technology and the size and structure of the market as key drivers. Then, in section 3, we describe our estimation strategy and data. Our data, covering the period 1980 to 2018 for 18 Sub-Saharan African countries, is mainly sourced from the Expanded African Sector Database and the Economic Transformation Database. Several estimators are used to control for endogeneity, heteroskedasticity, fractional and omitted variables and to take into account the long T (time periods), small N (number of countries) structure of our panel data. In section 4 we report and discuss our regression results. We also report extensive robustness checks. Section 5 concludes with a summary and some final remarks on the prospects for industrialization in Africa.

So as not to hold our reader in suspense, we can summarise our main findings. Africa's industrialization has been slow due to historical legacies (colonialism); geographical factors such as rainfall and large distances; trade and technology, such as imports from China which displaces manufacturing employment and digital technologies that benefit expansion in services sectors more. These obstacles are accentuated by recent global developments, such as the rise of digital platforms and their implications for global value chains (Naudé, 2023), the war in Ukraine and its implications for supply chains (Resnick, 2022; Stackpole,

[1] Mensah (2020) considers the following determinants of industrialization for his sample of 18 African countries: GDP per capita, population, productivity growth, trade, exchange rates, FDI, investment and human capital.

2022), trade and technology disputes between the USA and China (Demarais, 2022; Kwan, 2019), industrial policy nationalism with new generations of "green" industrial policies in the USA, such as the Inflation Reduction Act and the CHIPS and Science Act (Johnson, 2023), and in the EU, such as its 2023 Green Deal Industrial Plan (EC, 2023), rising energy costs (Yergin, 2022), and the possibility of a new "green minerals" scramble for Africa (Zeihan, 2022).

On the other hand, Africa faces hopeful prospects for industrialization due to rising GDP per capita, a large and growing population, flexibility in the small informal manufacturing sector, learning from exporting opportunities from the expanding regional market, steady improvements in human capital, and increasing urbanisation. A ray of light is the establishment of the African Continental Free Trade Agreement (AfCFTA). Reaping the benefits of these for future industrial expansion, however, depends on countries improving infrastructure to overcome the challenge of distance, improve trade facilitation to exploit learning-by-exporting from intra-African trade, facilitate urbanization, and navigate the fragmenting global geopolitical order. Succeeding in these will require appropriate strategic industrial policies - policies that can best leverage the continent's substantial latent assets. The research and policy agenda to support Africa's industrialization remains extensive.

2 Relevant Literature

Given that industrialization is a process of structural transformation that defines economic development, we make use in this section of the rich literature on the determinants of economic development in Africa to identify categories of drivers of industrialization.

Before proceeding, it is useful to define what is meant by industrialization (and deindustrialization). Industrialization as used in this paper refers to the rise in the share of *manufacturing* in value added and employment over a sustained period of time. Deindustrialization occurs conversely when the share of manufacturing in value added *and* employment declines (Tregenna, 2011, 2013).

Over the longer term industrialization outcomes are typically measured by the share of manufacturing value added in GDP (the MVA share in short) and the share of manufacturing in employment (EMP share in short). Shorter-term outcomes are reflected in the annual growth rates in these.

Bearing these descriptions of industrialization, de-industrialization and their measurements in mind, we will in what follows first provide an overview of the trends in African industrialization. This provides useful background against which to evaluate concerns about possible deindustrialization and interpret the empirical findings that we report in section 3. Then, we will scrutinize the literature on economic development and industrialization in Africa to identify the key categories of possible determinants - which we will then attempt in section 3 to measure and include in our estimation models.

2.1 Trends in Industrialization

Traditionally, manufacturing has been a driver of growth and development, including through intersectoral linkages; relieving balance of payments constraints; technological progress; providing for better paid jobs and working conditions (as compared say to agriculture and mining) (Naudé et al., 2015; Gollin, 2018); by improving productivity [2] and growth (de Brauw et al., 2014); by stimulating investment in skills development and capital intensification (Szirmai, 2012). Not surprisingly, therefore, the association of manufacturing with high-growth in developing countries is strong (Rodrik, 2014). The Commission on Growth and Development for instance found that "In countries that in the last 50 years sustained episodes of 7 percent growth or more over 25 years or longer, manufacturing and services led the way" (CGD, 2008, p.60). Moreover, manufacturing was more important than services. The only country among this group of fast growers over a period of 25 years where manufacturing growth did not outstrip services growth was Botswana (Naudé, 2019).

Following independence[3] most African governments and international development organisations recognised the importance of manufacturing, and a number of African countries made some progress in industrialising. However, Africa never developed to become a global manufacturing hub, nor did manufacturing play a similar growth-promoting role as it did in case of the East Asian Tigers and China (Szirmai et al., 2013; Kaplinsky and Morris, 2009). At the time of writing, Africa's share of global manufacturing is less than 2 percent, and compared to say Asia, SSA countries are "under-industrialised at all levels of income"

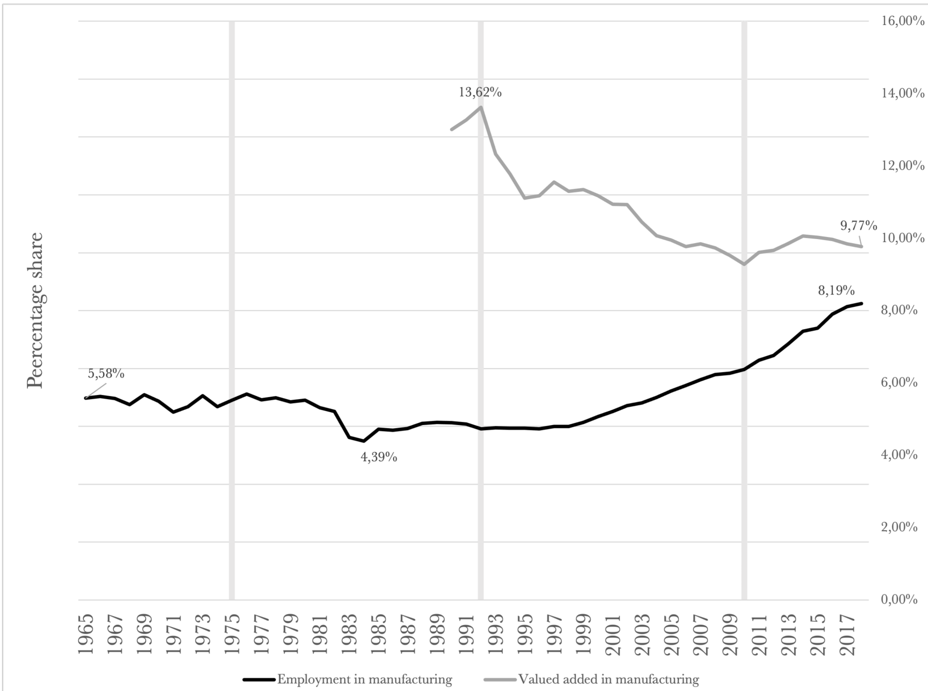
[2] McMillan and Rodrik (2011) report that labor is on average 2.3 times more productive in manufacturing than in agriculture in Africa.

[3] We focus our attention on industrialization post-independence. For insightful accounts of manufacturing in precolonial and colonial Africa, see e.g. McDougall (1990), Kilby (1975) and Bénétrix et al. (2015). The latter estimate that average industrial growth rates in Sub-Saharan Africa declined consistently since the early 20th century into the 21st, for e.g. from an average of 13.8% growth between 1913 and 1920, to an average of 3.0% between 1990 and 2007 (Bénétrix et al., 2015, p.26).

(Rodrik, 2016, p.10).

Manufacturing in Africa nevertheless has not been static, going through at least four post-independence phases (we suggest a fifth phase may have started around 2020). These phases are depicted in Figure 1, using the share of manufacturing employment, and the MVA share as indicators of industrialization.

Figure 1: Phases of Industrialization in Sub-Saharan Africa, 1965-2018



Data sources: Expanded African Sector Database (Mensah and Szirmai, 2018) and Economic Transformation Database (de Vries et al., 2021).

As shown in Figure 1, the first phase of industrialization after independence (roughly 1965-1975) was marked by post-independence consolidation and volatility. The second phase (1975-1995) was a phase of structural adjustment[4] which derailed the industrialisation agenda and led to very premature deindustrialization in many African countries, following the energy crisis and associated debt crises in many African countries.[5] The third phase (1995 -2008) saw recovery and modest growth in employment in manufacturing while the share of MVA in manufacturing continued to decline (i.e. low productivity). A fourth phase, following the 2010 global financial crisis, saw accelerated growth in the share of manufacturing employment as well as a modest recovery in the share of MVA. This fourth phase coincides with the convergence of digital technologies and connectivity from particularly 2007 onward

[4]See e.g., Herbst (1990).

[5]Writing in 1989, Mytelka (1989) described Africa's industrial sector as in "crisis."

(Friedman, 2016).

We posit a possible fifth phase that started around 2019-2022 with the trade and technology wars between the USA and China (Demarais, 2022; Kwan, 2019), Brexit, the COVID-19 pandemic, and the 2022 war in Ukraine. The start of this phase is marked by increased global instability reflected in greater sluggishness in global supply chains, rising energy and food prices, and a slowdown in global economic growth. In light of the determinants of industrialization that we identify in this paper, we return in section 5 - with some concern - to the prospects for future industrialization in Africa in this fifth phase.

2.2 Determinants of Industrialization

Given the trends in African industrialization described in the previous sub-section, we evaluate the literature to identify the possible determinants of the broad trends observed. Specifically, why did Africa fail to industrialize significantly? And what may be driving the few possible episodes of industrialization, such as the increase in the share of employment in manufacturing since around 1991?

Why Africa failed to develop its manufacturing sector over a thirty-year period (1965 - 1995) and thereafter remained marginal in global manufacturing, are questions that have preoccupied scholars and policy makers.[6] Answers that have been provided range from historical events, adverse geography, to a risky business environment. These are summarized in Table 1 with reference to a small but representative sample of papers that have dealt with the various determinants of (slow) industrialization.

The essence of the literature highlighted in Table 1 is that a combination of historical legacies, adverse geography, weak institutions, incoherent policies, technological gaps and market shortcomings can explain the slow progress evident in Figure 1, as well as the comparative under-development of manufacturing. In other words, to the extent that African countries were spared the slave trades and colonialism, adverse geography, and were able to maintain could policies and grow the market, the share of manufacturing would have risen, as it did in Asia.

These broad causes or determinants listed in Table 1 are of course interrelated - for instance weak institutions are the outcome of both historical legacies in combination with

[6] It is a sub-question of the overarching questions *why did Africa become poor?* and *why does Africa remain poor?* as excellently discussed by McMillan (2016).

Table 1: Influences on Industrialization in Sub-Saharan Africa

Broad Influence	**Constraining Impact**	**Key Literature**
Historical legacies	Slave Trades	Nunn (2007, 2008)
	Colonialism	Michalopoulos and Papaioannou (2020); McMillan (2016)
Geography	Disease burden	Gallup and Sachs (2001)
	Geographic axis	Laitin et al. (2012)
	Rainfall	Barrios et al. (2010)
	Distance from port, markets	Nunn and Puga (2012); Naudé (2009)
Institutions	Natural resource curse	Frankel (2010)
	Extractive institutions	Acemoglu and Robinson (2011)
	Violent conflict	Hoeffler (2015)
	Rent-seeking and corruption	D'Agostino et al. (2016)
Policies		
	Macroeconomic instability	Asongu and Odhiambo (2019)
	Uncertain business environment	Eifert et al. (2008)
	Distorting policies	Bruton (1998); Lawrence (2005)
	Lack of credit and finance	Bigsten et al. (2003)
Technology		
	Lack of absorptive capacity	Comin and Mestieri (2018)
	Barriers to tech diffusion	Allen (2012); Keller (2004)
	Inadequate infrastructure	Marconi et al. (2016)
Size of the market		
	Limited domestic market	Marconi et al. (2016)
	Competition from China	Kaplinsky and Morris (2009)
	Undiversified exports	Hausmann et al. (2007)

Source: Authors' own compilation.

geographical factors (Swee and Panza, 2016), and incoherent policies the outcome of weak institutions (Acemoglu and Robinson, 2013). Technology gaps are similarly the outcome of both institutions, policy choices and geographic factors (Comin and Mestieri, 2018).

In this light the narrative often starts by stressing that poor development outcomes (which include lack of industrialization) has been due to inappropriate policies,[7] wrong incentives,

[7]Lall (2004) argued that these inappropriate policies include the (i) under-appreciation of investments in human and physical capital formation, (ii) making of entry and exit of entrepreneurial start-ups difficult; the (iii) implementation of (time) inconsistent macro-policies, and (iv) wrong interventions in technology transfer.

and the natural resource curse (Frankel, 2010; McMillan and Rodrik, 2011; McMillan and Harttgen, 2014; Lall, 2004). These include distorting import substitution industrialization (ISI) behind protected markets and state-owned enterprises (Lawrence, 2005), excessive macro-economic volatility and capital-flight (Asongu and Odhiambo, 2019), and insufficient investment in human and physical capital (Benhabib and Spiegel, 1994; Lutz et al., 2021).

Inappropriate policies have tended to accentuate the fact that most African countries started out post-independence with relatively limited domestic markets as measured by population size and GDP per capita (these are thus two main determinants of industrialization). This has meant that the extent to which countries could export - their comparative advantage and competitiveness - have been important in Africa. As Marconi et al. (2016, p.76) pointed out, "the import substitution process may become exhausted, and foreign demand for domestic exports is needed to avoid external constraints, which ensures that the manufacturing sector output may rise and enable the process of structural change to continue." Thus, policies that have contributed to slow growth in exports, and moreover mitigated against diversification of exports away from dependency on raw material exports or away from exporting to other African markets where less sophisticated products are in demand, may have contributed towards slow industrialization in Africa.

Inappropriate policies and skewed incentives - the proximate causes of weak industrial performance - in turn have been argued to be due to weak and extractive institutions, with their roots in slavery and colonialism (Nunn, 2007, 2008; Acemoglu and Robinson, 2011). These are the ultimate or deep causes of poor structural transformation. Difficult property rights enforcement, tenuous rule of law, and limited accountability that characterises weak and extractive institutions, created risky business environments wherein conflict, corruption and red tape discouraged productive investment, indigenous entrepreneurship, as well as innovation and technology adoption (Eifert et al., 2008; Hoeffler, 2015; D'Agostino et al., 2016). As the financial sector, given its mobility and risk-sensitivity, is particularly dependent on institutions that provides stability and protect property rights (Bhattacharyya and Hodler, 2014), extractive regimes have almost inevitably been associated with lack of financial development in Africa. As such, measures of financial development are good proxies for institutional quality.

The evolution of institutions and the (slow) diffusion of technology[8] have been affected by Africa's geographical features (Swee and Panza, 2016; Naudé, 2009). The continent is

[8]Factors that can facilitate or constrain the adoption of technology in the manufacturing sector include the availability of human capital, entrepreneurship, complementary investments, e.g. in infrastructure, and macro-economic stability (Marconi et al., 2016).

characterised by the substantial length of its north-south axis relative to its east-west-axis, moreover in contrast with the Eurasian landmass which largely spans across an east-west axis. According to Laitin et al. (2012, p.10263) Latin America and Africa's "north-south orientations made technological diffusion inappropriate and counter-productive," suggesting that technological adoption and abilities may be an important determinant of industrialization.

A large part of the continent is within the tropics, which not only implies a greater disease burden, for instance from malaria (Gallup and Sachs, 2001; Sachs and Malaney, 2002), but lower agricultural productivity.[9] (Gallup and Sachs, 2000; Gollin et al., 2014). Given that the tropics receives more rainfall than other latitudes, this may lead one to expect a negative relationship between rainfall and industrialization to hold in Africa. This relationship may be accentuated by climate change. In this regard Henderson et al. (2017) found that climate change, as reflected in declining rainfall, leads to urbanization towards cities wherein manufacturing plays a larger role. In other words, industrialization may have been facilitating adaptation to climate change in Africa. The inflow of workers towards manufacturing-based cities are also likely to benefit the further development of manufacturing in those cities.

Another relevant geographical feature in the present context is the ruggedness of the terrain in Africa. This may be a mixed blessing of sorts, in that countries and regions with extremely rugged terrain were less affected by slavery (Nunn and Puga, 2012). Ruggedness and related topological features however raises transportation costs and the de factor distance from ports and global markets, through raising the costs of infrastructure investments in roads and ports, and the extent of physical distances to be covered (Limao and Venables, 2001; Naudé, 2009).

Geography also interacts with other factors - such as colonialism. One line of argument is that in places where colonial powers experienced high settler mortality - through for instance as a result of tropical diseases such as malaria - they imposed much more extractive institutions - and vice versa (Acemoglu et al., 2002). One could thus expect a differential impact of colonialism on industrialization, depending on whether it was characterised by extractive institutions or transfer of institutions that facilitate long-term investments. And the arbitrary drawing of national borders by the colonial powers in the 1880s created artificial

[9] Productivity in agriculture is ultimately necessary for structural change, as theoretically illustrated in the Lewis-model (Lewis, 1954) and its elaboration in Gries and Naudé (2010). It is also practically illustrated by the failure of Africa's largest tomato processing plant in Nigeria, which operates at only 20% of its 1,200-ton a day capacity, because farmers cannot supply enough tomato berries (Adamu, 2021). Dercon and El Beyrouty (2009) is thus mistaken in calling for less emphasis on agriculture in Africa.

states - many of them landlocked and with borders cutting across ethnic groups, leading to larger effective distances from international markets that raised both higher transport and investment costs, and the costs of coordination and state formation (Alesina et al., 2011; Michalopoulos and Papaioannou, 2020).

Furthermore, colonialism in Africa stunted the prospects of industrialization, at the time when other developing regions were industrializing between 1914 and 1945 (Mkandawire, 1988). Unlike other developing countries, African countries were unable to protect their domestic markets as a basis for industrialising, nor to finance industrial development by running deficits (Mkandawire, 1999). Thus, African countries had amongst the lowest levels of industrialisation globally by the time of independence (Mkandawire, 1988). By implication, the duration of colonialism would be expected to negatively affect later levels of industrialization.

In the context sketched in the preceding paragraphs, it is no surprise then that countries faced poor prospects to develop given the impact of the slave trades and the resource-extraction economies established in many countries under colonialism (Taylor, 2016). Indeed, this narrative implies the emergence and existence of development traps (self-reinforcing equilibria). The legacies of the slave trades, colonialism and adverse geography was by the 1960s to leave the newly independent African states with low levels of skilled labor (McMillan, 2016), high levels of distrust (Algan and Cahuc, 2010; Nunn and Wantchekon, 2011), imposed patterns of spatial development and infrastructure that facilitated exports of raw materials and low urbanization[10] (Michalopoulos and Papaioannou, 2020) and high transaction costs (Eifert et al., 2008; Naudé, 2009).

Thus the most viable industries were those relying on low levels of skills, using unsophisticated technologies, locking countries into economic activities characterised by low complexity, low productivity, and low wages. As explained by Kremer (1993, p.557) strategic complementarity in human and physical capital investment decisions can contribute to such a low-value equilibrium outcome, also explaining the Lucas Paradox[11] (Lucas, 1990) because "higher skill workers are less likely to make mistakes that waste the rental value of capital, and it is therefore optimal for them to use more capital." And as Allen (2012, p.9) pointed out, "the easiest technology for poor countries to adopt is that of the nineteenth century,

[10] There is a strong negative correlation between the proportion of a country's population living in rural areas and its level of per capita income in SSA (de Brauw et al., 2013). Christiaensen et al. (2013) found from Tanzanian household data that around 50 per cent of people who escaped from poverty between 1991 and 1994 did so by migrating out of agriculture, and into non-farming and urban-based activities.

[11] The Lucas Paradox refers to fact that although capital is scarcer in developing countries, this does not always lead to more capital flowing to developing countries - see Lucas (1990).

which was invented when wages were much lower relative to the price of capital." Thus more capital-and-technology intensive, hence more complex and productive activities, will not be economically viable in the post-colonial environment, where returns on less complex, and even unproductive and destructive activities will be higher (Acemoglu and Robinson, 2011; Baumol, 1990). Moreover, lack of skills and efficient labor market sorting will limit the emergence of larger, more productive firms that are necessary for the coordination of complex manufacturing[12] (Lucas, 1978).

Lack of complementary investments in education[13] and infrastructure, including in broadband infrastructure, continues to be significant factors in the digital gap that African countries face, and hence their ability to develop more complex manufacturing (Banga and te Velde, 2018; Graham et al., 2017). Consequently, some have argued that new and emerging technologies, such as artificial intelligence (AI) and robotics are making manufacturing more complex and less labor intensive, and therefore a less desirable sector for Africa to try and develop (Hallward-Driemeier and Nayyar, 2018; Banga and te Velde, 2018). The 4th industrial revolution is thus, in these assessments, a threat to further industrialization in Africa.

Finally, in this section so far we have identified the determinants of industrialization from the literature that focus on the reasons for why economic development, including industrialization, has been challenging in Africa. Despite this negative perspective, it is however the fact that there has been some industrialization in Africa, even to the extent that Rodrik (2016) could refer to Africa's *de*industrialization, and even "premature" deindustrialization.[14]

This presupposes that the process of industrialization is some stylized process, perhaps changing over time in terms of impact and importance as a country changes (Rowthorn and Ramaswamy, 1997). This is indeed the theoretical point of departure for Rodrik (2016) and others who have attempted to determine whether the process of industrialization is changing in Africa. As such, the flip-side of the coin of the question what determines Africa's industrialization are the questions whether Sub-Saharan Africa is deindustrializing, and why?

Given that it is not our aim in this paper to focus on the debate on whether Africa is

[12]Countries with a higher skilled labor force tend to have larger, more productive firms, see Gomes and Kuehn (2017).

[13]For a recent review of post-colonial progress in education in Africa, as well as remaining challenges, see Evans and Acosta (2021) and Lutz et al. (2021).

[14]Premature deindustrialization can de described as deindustrialization that occurs "much earlier than the historical norms" and that "may have detrimental effects on economic growth" (Rodrik, 2016, p.3).This is a deviation from normal deindustrialization which is part of the natural pattern of structural change as a country develops (Rowthorn and Ramaswamy, 1997).

deindustrializing or not - the reader is referred to the excellent discussion of this in the studies by Rodrik (2016), Nguimkeu and Zeufack (2019), Mensah (2020), Diao et al. (2018), Kruse et al. (2021) and Timmer et al. (2015) - we will limit our discussion hereof to the general empirical approach that studies on this topic has taken, and the key variables associated with (de) industrialization. These have generally, as we pointed out in the introduction, relied on the literature dealing with (de) industrialization in advanced economies.

In this literature, which has been inspired by Kuznets (1966) and Kuznets (1973) the view is that there is an inverted U-shaped relationship between level of development (as measured for instance by GDP per capita) and the share of industry (manufacturing) in the economy. Three reasons have been given for the existence of such an inverted U-shaped relationship. One is that it could be the result of different rates of growth in total factor productivity (TFP), often taken to reflect technology, with relative price changes as consequence (affecting the supply-side) (Ngai and Pissarides, 2007). A second is due to non-homothetic consumer preferences - i.e. resulting in a declining Engel's coefficient as household incomes rise (thus affecting the demand-side) (Kongsamut et al., 2001; Foellmi and Zweimuller, 2008; Matsuyama, 2000). A third reason, one first raised by Kuznets (1973, p.250) is that of a country's "changing comparative advantage in foreign trade." Matsuyama (2009) has theoretically demonstrated that in an open economy the country where productivity in the manufacturing sector grows fastest compared to the services sector, may under certain conditions cause deindustrialization in its trading partners' economies.[15]

To capture and measure whether this inverted U-shape exist, and to calculate from such measurements the turning point in terms of GDP per capita, from which can be deduced if deindustrialization is premature or not, the practice is to regress measures of industrialization against GDP per capita and GDP per capita square. Evidence in favor of deindustralization would be if the coefficients on these are respectively positive and negative, and statistically significant. According we will include GDP per capita and its square in our subsequent empirical analysis of the determinants, bearing in mind that GDP per capita is also likely to be highly reflective of institutional quality in a country.

[15] For example, increased trade between Africa and China, the world's manufacturing powerhouse, may cause deindustrialization in Africa (Edwards and Jenkins, 2015; Edwards et al., 2020). We will explore this possibility in what follows.

3 Methodology and Data

3.1 Estimating equations

The theoretical explanations for the inverse U-shaped relation between GDP per capita and the share of manufacturing, as discussed in section 2, provides the foundation for an estimating equation to identify the determinants of industrialization as well as to evaluate whether or not a country is deindustrializing or not. This is also the approach used by Mensah (2020) and Tregenna et al. (2021).

Our basic point of departure is, roughly following Rodrik (2016, p.9), a Kuznets-type equation (see e.g. (Kuznets, 1955)) of the form

$$m_{i,t} = \beta_0 + \gamma_t + \beta_1 lny_{i,t} + \beta_2 (lny_{i,t})^2 + \epsilon_{i,t} \tag{1}$$

Where $m_{i,t}$ is the measure of industrialization. It is measured in this paper by the real share of manufacturing value added (MVA) in GDP and by the share of manufacturing employment in total employment, as well as their growth rates. Furthermore, in equation (1), $lny_{i,t}$ is the natural logarithm of GDP per capita, β_0 and γ_t are intercept parameters varying respectively across countries and years, and $\epsilon_{i,t}$ an idiosyncratic error term. If $\beta_1 > 0$ and $\beta_2 < 0$ it would be an indication of an inverted U-shape relationship between GDP per capita and the share of manufacturing.

Because our main interest is in the broader, context-informed determinants of industrialization, equation (1) is augmented with various conditioning variables, which we take from Table 1.

Thus, equation (1) can be written as:

$$m_{i,t} = \alpha_{i,t-1} + \beta^{'} X_{i,t} + \delta_i + \epsilon_{i,t} \tag{2}$$

Furthermore in (2, i and t denote the country (i=1,. . . ,18) and year (t=1965,. . . ,2018). X denotes a vector of determinants of industrialization that are of particular interest. δ_i, and ϵ_{it} represents country fixed effects and the idiosyncratic error term respectively. Our aim is to estimate the coefficients of (de)industrialization determinants (β). Various estimators will be used, in order to control for unobserved time-and country-specific effects, reverse causality, endogeneity, heteroskedasticity, omitted and fractional variables. In section 3.3. we explain our estimation strategy. First though we describe our variables and data, because our estimation strategy depends on these.

3.2 Variables and Data

Our dependent variables are the share of manufacturing value added (*MVAshare*) and the share of employment in manufacturing (*EMPshare*) and their growth rates. These are generally accepted measures of industrialization. We obtained data on these variables covering the period 1965 to 2018 from the Expanded African Sector Database (Mensah and Szirmai, 2018) and the Economic Transformation Database (de Vries et al., 2021).

The determinants of industrialization (our independent variables - the X in equation (2)) have been selected based on our review of the relevant literature in section 2. Thus, for the remainder of the discussion in this sub-section, we will refer back to section 2, and base our selection of variables to use in equation (2), on Table 1.

Our key independent variables, and their sources of data, are listed in Table 2. Thus, as per Table 1 and the discussion in section 2, we categorise variables into historical legacies, geography, institutions and policies, technology, and market size. These categories are, we should again stress, not watertight. For instance, institutions and policies may depend on market size and technology, and vice versa; and geography and historical legacies may interact.

Under each of the main categories in Table 2, many measures are potentially available. Here we made a selection based on availability and reliability considerations, as well as keeping in mind parsimony, and aiming to avoid multicollinearity problems.

It can be seen from the table that our main data sources are Nunn (2008), Nunn and Puga (2012), the World Bank Development Indicators Online, the Penn World Table 10.0, the CEPII BACI HS96, The Total Economy Database of the Conference Board, and the World Bank's Climate Knowledge Portal. Our variable to measure the impact of colonialism is the years that a country was under colonial rule, taken from Ziltener et al. (2017). This measure captures the "length and depth" of colonialism.[16] We investigated the *ADB-ADBI Inno-*

[16]Ziltener et al. (2017) finds that in countries that were under colonial rule for a long time received more investment, but also experienced a more difficult decolonization process. The net effect on manufacturing is

vation and Structural Transformation Database but found this to be unsuitable, given that African countries are not adequately covered, and that the database covers only the period 2007 to 2019, which is insufficiently long for a database attempting to measure structural transformation; it is, after all, a process unfolding over multiple decades.

3.3 Estimation strategy

To start out, we would like to exploit the panel data property of our data to the extent possible. Because we are also interested in the effect of time invariant factors, such as historical events and geographical features on industrialization, this makes a random effects (RE) panel estimator, *a priori*, most desirable.

Accordingly we started out by estimating equation (2), for both dependent variables, using a RE generalised least squares (GLS) estimator. After this we performed the Breusch-Pagan test (see Breusch and Pagan (1980)) for the appropriateness of the RE estimators. This indicated that the variance for the error term is 0, and the overall p-value for the regression is 1. This meant that we could not reject the null, and that the coefficient estimates would be similar to that of a pooled OLS (POLS) regression. This was confirmed by a Hausman-test which failed to meet its asymptotic assumptions. It was also confirmed by implementation of the *xtoverid* package in STATA 16 (Schaffer and Stillman, 2016), which established that "RE estimates are degenerate ($sigma_u = 0$) and equivalent to pooled OLS".

The downside however of using a POLS, even with cluster robust standard errors, is that if the errors in equation (2) are correlated with the independent variables, using POLS would cause omitted variables bias. Therefore, to minimise this problem, we tried a fixed-effect (FE) generalised least squares (GLS) estimator with robust standard errors with our four independent variables (results available on request). However, post-estimation for the FE GLS estimates, we tested for groupwise heteroskedasticity in the residuals of the fixed-effect regression, using a modified Wald statistic (Baum, 2000, 2001). This rejected the null of no heteroskedasticity, implying that the error term of our model suffers from groupwise heteroskedasticity and significant contemporaneous correlation.

One possible reason for this, and hence for the inadequacy of the FE estimator, could be due to the nature of our panel dataset, which is characterised by a panel structure with the number of time periods larger than the number of countries, i.e. $T > N$. The FE GLS

thus *a priori* ambiguous.

Table 2: Independent variables and data sources

Variable	Description	Source
Historical legacies: Slavery and Colonialism		
slavex	Estimates of the number of people exported as slaves between 1400 and 1900 in Africa's four slave trades.	Nunn (2008)
colyears	Number of years subject to colonial rule	Ziltener et al. (2017)
Geography		
dist	Average distance to nearest ice-free coast (1000 km)	Nunn and Puga (2012)
rainfall	% Annual rainfall in mm	World Bank Climate Knowledge Portal
Institutions and policies		
gdppc	GDP per capita, PPP (constant 2017 international $)	World Bank WDI Online (series NY.GDP.PCAP.PP.KD.)
credit	Domestic credit to private sector by banks (% of GDP)	World Bank WDI Online (series FD.AST.PRVT.GD.ZS)
humancap	Human capital index	Penn World Table 10.0, see (Feenstra et al., 2015)
Technology		
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank WDI Online (series BX.KLT.DINV.WD.GD.ZS)
tfp	Total factor productivity growth	The Conference Board
hightechx	Share in % of total exports that are high-tech manufacturing	CEPII BACI HS96 revision Feb 2021
digital	Digital Adoption Index 2014-2016	World Bank WDR2016 at World Bank (2016)
Market size, structure and competition		
rural	Share of population residing in rural areas	World Bank WDI Online (series SP.RUR.TOTL.ZS)
pop	Total population (in millions)	World Bank WDI Online (series SP.POP.TOTL)
china	Share of imports from China	Johns Hopkins China-Africa Research Initiative, from UN Comtrade Data

Source: Authors' own compilation.

estimator may not be optimal or adequate, as it assumes $T < N$ (Bai et al., 2020).

To account for this structure of our panels, we therefore used a Feasible Generalized Least Squares (FGLS) estimator. This estimator, implemented with the *xtgls* command in STATA, can deal with $T > N$ by estimating the model considering that there may be AR (1) autocorrelation within a panel, and cross-sectional correlation and heteroskedasticity across the panels. The results from the FGLS estimator, both for the cases of no AR and AR (1) are reported in the first two columns of Tables 3 to 6.

To take into account possible endogeneity of our regressors and the effects of lags, we also estimated a systems DPD estimator (reported in the third column of Tables 3 to 6). This estimator is implemented with the *xtdpdsys* command in STATA. The Sargan-Hansen test (Sargan, 1958; Hansen, 1982) was used to test the null that the overidentifying restrictions on the instruments used in the dynamic panel data estimates were valid. These tests could not reject the null, except at a 10% level in one case.

Finally, recent empirical studies of African industrialization, by Nguimkeu and Zeufack (2019) and Mensah (2020) used a fixed effects fractional logistical regression (logit) model, arguing that this estimator is necessary to avoid potential bias from the fact that the dependent variable, the manufacturing (employment) share, is a fractional response variable, ranging between 0 and 100 (0 and 1) - and that the logit model can better capture non-linear effects being based on the logistical (sigmoid) distribution. Given the ease of using this estimator, and to facilitate comparisons with Nguimkeu and Zeufack (2019) and Mensah (2020) we also report its estimates in the cases where we have a fractional response variable, specifically in the cases of the MVA share and the share of employment in manufacturing. We note however that these results are subject to the weakness that, as Papke and Wooldridge (2008, p.122) discusses, the factional logit model is most appropriate for "panel data with a large cross-sectional dimension and relatively few time periods," the opposite of the present case, where we have the number of time periods larger than the number of countries, i.e. $T > N$.

4 Empirical Results

4.1 Descriptive Statistics

The summary of the variables used and their correlations are contained in Appendix A. From Table 9 in Appendix A can be seen that in most cases we had more than 900 observations per variable. Regarding our first dependent variable, the mean share of MVA (*MVAshare*) over the period 1965 to 2018 was 10.9%, with a minimum of 0.46% and a maximum of 26.4%.

Regarding our second dependent variable, the employment share in manufacturing (*EMP-share*) it can be seen that the mean share over the period was 6.5%, and that it ranged from a low of 5.5% to a high of 31.5%. The latter was attained by Mauritius in 1990.

The growth rate in the MVA share averaged 1.6% and in the share of employment in manufacturing 2.0%.

4.2 Regression Results

We can now report our regression results.

Tables 3 and 4 contain the regression results for the share of MVA, and the share of employment in manufacturing, while Tables 5 and 6 contain the regression results for the growth rate of the MVA share, and the growth rate of the share of employment in manufacturing. We thus have four dependent variables as discussed in the previous section.

In case of each dependent variable, we report results from three preferred estimators. The first is a Feasible Generalized Least Squares (FGLS) estimator, for which we report results both without and with autocorrelation (AR(0), AR(1)). The second is a system dynamic panel data estimator (s-DPD) and the third a factional logit model (FRAC). In what follows we justify this regression strategy and explain why we do not report results from use a pooled OLS or Random Effects (RE) or Fixed Effects estimator (s) - although these results are available on request. Note that variables were, where possible, logarithmically transformed.

Our findings are reported in Tables 3 and 4 (for the Share of MVA and the share of employment in manufacturing- logarithmically transformed in the case of the first three columns) and in Tables 5 and 6 (for the *growth rates* in the MVA share and share of employment in manufacturing).

From Table 3 we can draw the following conclusions. First, there are five variables that are robustly significant across all the estimators. These are the first-order lagged value of the MVA share (*MVAshare(L1)*), the number of years a country has been subject to colonial rule (*colyears*), annual rainfall (*rainfall*), and GDP per capita (*gdppc*) and its square ($gdppc^2$). The sign on the lagged value of the MVA share is positive reflecting short-run persistence. The sign on the years of colonial rule coefficient (*colyears*) is positive, and on rainfall it is negative. The signs on GDP per capita and its square respectively positive and negative. We can note that the share of rural population and the distance from the coast variable are significant across three of the estimators and negative - consistent with the ideas that distance from ports and lack of urbanization are constraining factors in industrialization.

The impacts of colonial rule and rainfall on the MVA share - respectively positive and negative - may be surprising. The positive impact of colonial rule on manufacturing may be explained by the Acemoglu (2002) thesis that that in places where it was easier for colonial powers to get a foothold, they were able over a longer period to transplant institutions and do long-term investment, and that these places are today characterised by higher per capita incomes (or in our case, a higher MVA share). In the case of our sample of African countries, indeed the countries with a higher share of manufacturing value added are amongst the countries that experienced the longest colonial rule: South Africa (342 years) and Mauritius (330 years).

The negative impact of rainfall will be discussed below, as it is also a highly significant and robust determinant of short-term fluctuations in MVA and the employment share - see Tables 5 and 6.

The signs on GDP per capita and its square indicates that the development of the domestic market is important, and are consistent with de-industrialization. Given that none of the countries in our sample are high-income countries, this may suggest premature de-industrialization. For de-industrialization to be the case, would require that not only the share of MVA decline after a certain threshold of income, but also the share of employment in manufacturing. The results in Table 4, for the share of employment in manufacturing, provides evidence that this may indeed be the case, as GDP per capita and its square are significant according to both FGLS estimators and the fractional logit model, and enter with the expected signs.

We can also see from Table 3 that the distance from the nearest ice free coast (*distance*), the

Table 3: Dependent variable: MVA share

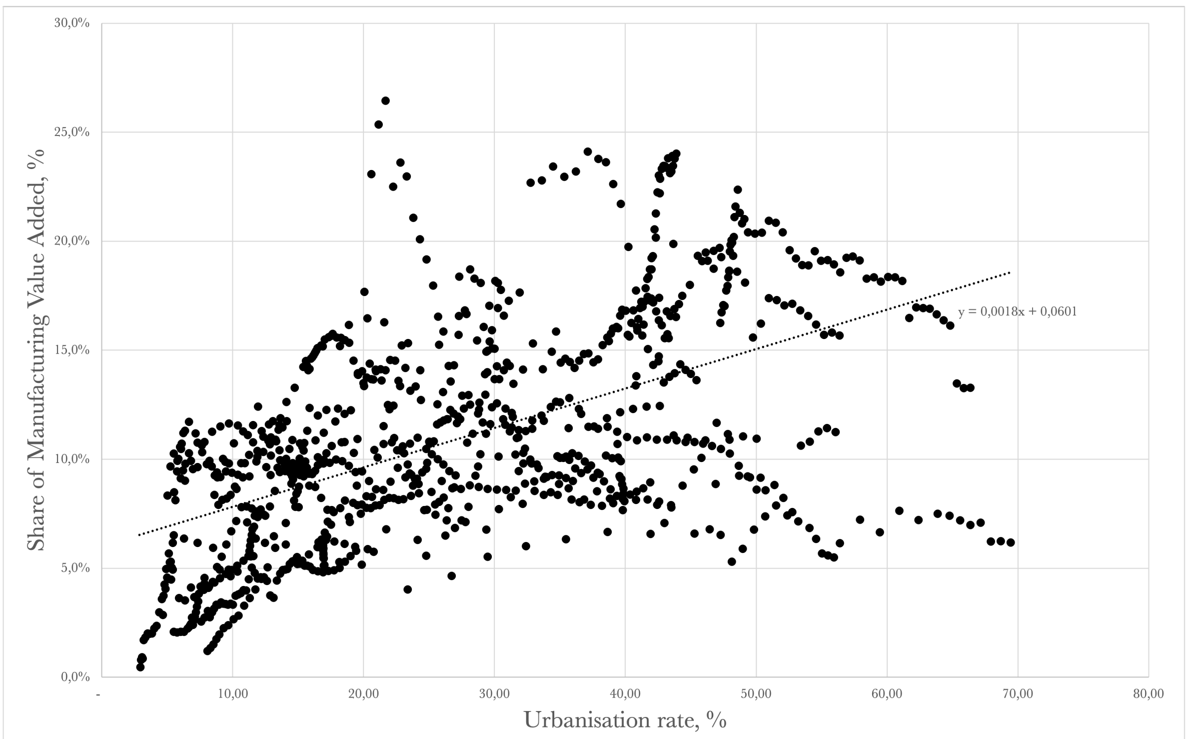
	(1) FGLS	(2) FGLS AR(1)	(3) s-DPD	(4) FRAC
MVAshare(L1)	**0.99*****	**0.98*****	**1.01*****	**8.43*****
	(14.78)	(14.67)	(17.4)	(11.49)
MVAshare(L2)	**-0.24***	**-0.23*****	**-0.27*****	-1.16
	(-3.46)	(-3.38)	(-4.48)	(-1.42)
slavex	-0.01	-0.01	-0.00	-0.01
	(–0.97)	(-0.97)	(-0.02)	(-0.89)
colyears	**0.21****	**0.21****	**0.30***	**0.17*****
	(3.43)	(3.42)	(2.48)	(2.80)
distance	**-0.09*****	**-0.10*****	0.15	**-0.09***
	(-3.41)	(-3.40)	(0.16)	(-2.32)
rainfall	**-0.08****	**-0.08****	**-0.10****	**-0.08***
	(-2.38)	(-2.37)	(-2.59)	(-2.56)
gdppc	**0.70***	**0.71***	**0.87***	**0.74***
	(1.97)	(1.97)	(2.10)	(1.79)
$gdppc^2$	**-0.05***	**-0.05***	**-0.06***	**-0.06***
	(-2.18)	(-2.18)	(-2.27)	(-2.13)
pop	0.06	0.06	-0.15	-0.16
	(0.22)	(-0.22)	(-0.42)	(-0.52)
pop^2	-0.01	-0.00	0.01	0.01
	(-0.14)	(-0.13)	(0.48)	(0.59)
china	-0.02	-0.02	**-0.02****	-0.01
	(-1.75)	(-1.74)	(-2.25)	(-0.84)
hightecx	-0.00	-0.00	-0.00	-0.01
	(-0.63)	(-0.63)	(-0.43)	(-1.28)
human	0.11	0.12	0.07	0.13
	(1.69)	(1.68)	(0.62)	(1.71)
FDI	0.00	0.00	-0.00	0.00
	(0.45)	(0.44)	(-0.45)	(0.10)
credit	0.00	0.01	0.03	0.04
	(0.36)	(0.36)	(1.05)	(1.57)
rural	**-0.17****	**-0.17****	-0.19	**-0.21*****
	(-2.17)	(-2.17)	(-1.44)	(-2.73)
tfp	-0.27	-0.27	-0.28	-0.36
	(-1.57)	(-1.58)	(-1.58)	(-1.88)
digit	**-0.23***	**-0.23****	-0.31	-0.13
	(-2.55)	(-2.53)	(-1.40)	(-1.08)
constant	-2.53	-1.59	-1.46	-2.95
	(-0.97)	(-0.97)	(-0.43)	(-0.91)
N	210	210	210	210
Wald chi^2	4315.4	4259.7	975.2	8694.8
Prob > chi^2	0.00	0.00	0.00	0.00

z-statistics in parentheses, robust standard errors in case of FRAC
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
natural logs of dependent variable in case of (1), (2), (3)

share of the population living in rural areas are significant according to both the FGLS and FRAC estimators. The negative signs on their coefficients imply that countries and regions more remote from international markets, and that are less urbanised, are at an disadvantage to develop manufacturing. The finding with respect to distance is in accordance with the literature - see e.g. Naudé (2009).

The finding with respect to urbanisation (rural population) is as one would expect, but is a surprisingly rare finding in the literature. For instance, Gollin et al. (2016) found that "the expected relationship between urbanization and industrialization is absent in large parts of the developing world" (Ibib, p.37). The reason for this is that urbanisation in many countries is driven by natural resource exports which results in consumption cities rather than production cities. Our results however suggests a positive relationship between urbanisation and industrialisation as part of the process of structural change - Figure 2.

Figure 2: *Urbanisation Rate and the Share of MVA in 18 SSA countries, 1965-2018*



Data sources: Expanded African Sector Database (Mensah and Szirmai, 2018) and Economic Transformation Database (de Vries et al., 2021).

The negative impact of rainfall should be commented on. Rainfall is a highly significant and robust determinant of short-term fluctuations in MVA and the employment share - see Tables 5 and 6. Rainfall is found to have a significant negative association with industrialization. Indeed, the more tropical parts of the continent remain more reliant on natural resources, with industrialization more advanced in the more arid Northern and Southern regions of the continent. Furthermore, the relationship in Figure 2 is also consistent with the already mentioned finding of Henderson et al. (2017) that climate change, as reflected in declining rainfall, leads to urbanization in Africa towards cities wherein manufacturing plays a larger role and that the inflow of workers into manufacturing-based cities are benefiting the further development of manufacturing in those cities.

Returning to the results in Table 3, the significance of, and negative coefficient on, the digital adoption index (digit) suggests that, insofar as this reflects technological innovation, that technological innovation are benefiting non-manufacturing sectors relatively more. Higher productivity is obtained at the expense of relative jobs in manufacturing. It is consistent with evidence that suggest the African countries are most advanced in technological innovation and adoption of technologies in financial and business services, of which the case of M-PESA has been noted (World Bank, 2016) and even in some mining activities undertaken by multinational corporations in African countries.

In Table 4 we report the regression results in the case of the share of employment in manufacturing as the dependent variable.

In Table 4 the only variables that are robustly significant across all the estimators are the lagged value of the employment share, distance from the nearest ice free coast (*distance*) and rainfall. The signs on the coefficients of the distance, rainfall are negative as was the case with the MVA share, but the sizes of the coefficients are much larger - indicating that they have a much more dampening effect on the employment share in manufacturing than on the value added share.

Noticeably, while the share of imports from China has no significant impact on the MVA share, it has a statistically significant and negative impact on the employment share in manufacturing according to the panel data and fractional logit estimators. The implication is that import competition from China is leading to a lower employment in manufacturing share - it is displacing jobs as firms attempt to compete. This may be both through intra-firm channels (firms become leaner or downsize) and through composition effects at the firm level (more labor-intensive and less productive firms being more likely to close) and at the sector level (more labour intensive sectors of manufacturing being more heavily affected) in the face of import penetration from Chinese manufactures. Our result is in accordance with that of Busse et al. (2016), Torreggiani and Andreoni (2019), Edwards et al. (2020) and Edwards and Jenkins (2015). The latter found that in the case of South Africa import penetration from China caused "manufacturing output to be 5 per cent lower in 2010 than it

Table 4: Dependent variable: Share of employment in manufacturing

	(1) FGLS	(2) FGLS AR(1)	(3) s-DPD	(4) FRAC
EMPshare(L1)	**1.39***	**1.33***	**1.37***	**18.32***
	(23.20)	(21.57)	(24.97)	(9.72)
EMPshare(L2)	**-0.44***	**-0.39***	**-0.45***	**-5.47***
	(-7.72)	(-6.61)	(-8.62)	(-3.11)
slavex	0.00	0.00	-0.03	**-0.03***
	(0.28)	(0.33)	(-1.54)	(-2.58)
colyears	0.04	0.04	-0.18	**0.12**
	(0.85)	(0.76)	(-1.09)	(1.84)
distance	**-0.10***	**-0.09***	**-0.17***	**-0.18***
	(-3.44)	(-3.40)	(-3.18)	(-4.67)
rainfall	**-0.11**	**-0.11**	**-0.08**	**-0.13**
	(-3.38)	(-3.38)	(-2.41)	(-2.26)
gdppc	0.02	0.00	0.10	**1.26**
	(0.06)	(0.00)	(0.23)	(2.62)
gdppc^2	0.01	0.01	-0.00	**-0.08**
	(0.25)	(0.31)	(-0.12)	(-2.57)
pop	**0.82***	**0.88***	**0.81**	-0.01
	(3.44)	(3.45)	(2.46)	(-0.03)
pop^2	**-0.22***	**-0.02***	**-0.02**	0.00
	(-3.29)	(-3.31)	(2.17)	(0.41)
china	-0.01	-0.01	**-0.02**	**-0.06***
	(-1.65)	(-1.72)	(-1.97)	(-5.18)
hightecx	0.01	0.01	0.10	**0.03***
	(0.96)	(0.98)	(1.59)	(3.42)
human	0.08	0.09	- 0.07	0.14
	(1.40)	(1.37)	(-0.64)	(1.34)
FDI	0.00	0.00	**0.01**	-0.00
	(1.42)	(1.39)	(2.38)	(-0.30)
credit	-0.03	-0.03	-0.03	-0.00
	(-1.22)	(-1.07)	(-1.29)	(-0.01)
rural	**0.16***	**0.17***	-0.09	0.00
	(2.30)	(2.32)	(-0.59)	(0.02)
tfp	0.13	0.12	-0.20	**-0.66***
	(0.86)	(0.77)	(1.28)	(-2.82)
digit	**-0.35***	**-0.37***	-0.25	**-0.71***
	(-4.43)	(-4.47)	(-1.30)	(-5.04)
constant	**-7.07**	**-7.50***	**-5.69**	**-7.23**
	(-3.11)	(-3.11)	(-1.92)	(-1.95)
N	210	210	210	210
Wald chi^2	16535.2	14156.7	5378.6	10992.5
Prob > chi^2	0.00	0.00	0.00	0.00

z-statistics in parentheses, robust standard errors in case of FRAC

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

natural logs of dependent variable in case of (1), (2), (3)

otherwise would have been. The estimated reduction of total employment in manufacturing as a result of trade with China is larger -in 2010 about 8 per cent" (Edwards and Jenkins, 2015, p.447).

As in the case of the MVA share, the employment share in manufacturing is negatively affected by digital adoption as measured by the *Digital Adoption Index* (*digit*) and the share of manufactured exports that are classified as high-tech (*hightecx*). This suggest that countries that are innovating more, and specifically more innovative in digital technology adoption, will see relatively less job creation in manufacturing.

Finally we can note that the results in Table 4 suggest that market size are also important for the share of employment, and that according to the systems dynamic panel data estimator (s-DPD) population size is a better indicator in this regard than GDP per capita. As far as the extent of people exported as slaves between 1400 and 1900 is concerned, we can see that this result is not very robust and small - only the FRAC estimator finds it to be significant. It was not significant at all in the case of MVA. Thus, the evidence of the persistent negative impacts of the slave trades on industrialization in contemporary Africa is very weak.

Tables 5 and 6 contain the regression estimates for the growth rates in the MVA share and employment share in manufacturing, respectively. We use the same literature-derived independent variables as already discussed. The FGLS and s-DPD estimators are used : the dependent variables, MVA share growth and employment share growth, are not fractional variables, but unbounded, hence the FRAC estimator cannot be used.

Table 5 gives the overall impression that the determinants of the growth rate of the MVA share are elusive. This is a typical finding in econometric studies where annual growth rates - reflecting short-term rates of change - are the dependent variables. As such they are bound to reflect a larger collection of impacts, including noise. Table 5 does however, contain interesting results, nevertheless. For instance rainfall, which we had already identified as a determinant of the longer-term level of the MVA share, is a highly significant and robust determinant of short-term fluctuations in the MVA share. Moreover, the sign of its coefficient is negative. Thus, countries with higher annual rainfall not only have a lower MVA and employment in manufacturing share over the longer-run, but experience slower annual (short-term) growth in the share of their MVA and share of employment in manufacturing. In short, countries with higher rainfall tend to be slower to industrialize and not to industrialize that extensively. This may reflect the fact that tropical countries in Africa receive on average more rainfall that non-tropical countries, and that industrialization may be, for various reasons, more difficult in the tropics, as many have argued to be the case for development in general - see e.g. Bloom et al. (1998), Gallup and Sachs (2000) and Gallup and Sachs (2001).

Table 5: Dependent variable: Growth rate of the MVA share

	(1) FGLS	(2) FGLS AR(1)	(3) s-DPD
$\Delta MVAshare(L1)$	**0.13***	**0.12***	**0.13***
	(1.84)	(1.70)	(2.20)
$\Delta MVAshare(L2)$	**-0.15***	**-0.15***	**-0.18*****
	(-2.34)	(-2.33)	(-3.14)
slavex	-0.12	-0.13	-3.47
	(-0.14)	(-0.15)	(-1.07)
colyears	2.11	2.10	18.36
	(0.36)	(0.35)	(1.62)
distance	-1.64	-1.62	-7.41
	(-0.60)	(-0.59)	(-0.56)
rainfall	**-8.31***	**-8.31***	**-10.8****
	(-2.08)	(-2.08)	(-2.57)
gdppc	1.39	1.64	-14.03
	(0.04)	(0.04)	(-0.28)
$gdppc^2$	-0.66	-0.68	0.27
	(-0.26)	(-0.27)	(0.09)
pop	-23.44	-23.76	43.96
	(-0.78)	(-0.78)	(1.02)
pop^2	0.78	0.79	-0.97
	(0.89)	(0.90)	(-0.77)
china	-0.80	-0.79	-2.03
	(-0.81)	(-0.80)	(-1.61)
hightecx	-0.15	-0.15	-0.82
	(-0.20)	(-0.20)	(-0.97)
human	8.12	8.08	19.18
	(1.07)	(1.05)	(1.40)
FDI	0.14	0.14	-0.14
	(0.46)	(0.44)	(-0.42)
credit	0.80	0.81	5.11
	(0.29)	(0.29)	(1.65)
rural	**-15.72***	**-15.85***	8.03
	(-1.77)	(-1.77)	(0.51)
tfp	-27.69	-28.05	-28.29
	(-1.43)	(-1.45)	(-1.40)
digit	-10.20	-10.06	**-50.1***
	(-1.03)	(-1.02)	(-1.77)
constant	343.6	345.82	-227.5
	(1.23)	(1.23)	(-0.57)
N	210	210	210
Wald chi^2	19.07	18.61	43.09
Prob > chi^2	0.38	0.42	0.00

t or z-statistics in parentheses, based on robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In Table 6 the regression results for the growth rate of the share of employment in manufacturing are contained. Whereas our model only identify a few statistically significant determinants of the growth rate of the MVA share, it better captures the determinants of the growth rate of the employment in manufacturing share. Five variables are robustly significant across all the estimators: the lagged growth rate ($\Delta EMPshare(L1)$), rainfall *(rainfall)*, the share of imports from China (*china*), credit extended to the private sector (*credit*) and the extent of digital adoption (*digit*). Moreover, population size and the share of the population living in rural areas are both significant according to the FGLS estimators.

We note that the coefficient on credit extended to the private sector (a measure of financial development) is negative and the coefficient on the share of the population living in rural areas, is positive. The signs on these coefficients are plausible: they suggest that more rural countries, and countries with a less developed financial sector, are growing manufacturing employment faster. This can be the effect of growing from a smaller base - the smaller based caused by the factors identified in Tables 4 and 5. The conclusion is that, as far as employment in manufacturing is concerned, a catch-up effect is present within the African sample.

4.3 Robustness checks

The estimators used in Tables 3 to 6 have been chosen, as we explained in section 3.3.1 (estimation strategy) so as to avoid multicollinearity problems and to handle a wide variety of potential mis-specification problems, including auto-correlation, heteroskedasticity, omitted variables, fractional dependent variables and endogeneity. The various regressions also turned out - mostly - to be overall significant and well behaved according to the post-estimation diagnostics that we reported.

The variables that we have selected, have been done parsimoniously in order to save degrees of freedom - we could have included many more variables. The variables chosen conform to the underlying theoretical understanding - or implicit model - of the determinants of industrialization in Africa (see Table 2), which in broad terms are historical legacies, geography, institutions and policy, technology, and market structure, size and competition. Our results have been consistent in pointing to these factors as statistically significant, with the significant affects due to market size and access, geographical factors such as rainfall and distance, import competition, technology adoption and innovation, and historical legacies. Thus, we can be confident that our estimation strategy has resulted in a reasonably good specification of the data generation process.

Table 6: Dependent variable: Growth rate of the share of employment in manufacturing

	(1) FGLS	(2) FGLS AR(1)	(3) s-DPD
$\Delta EMPshare(L1)$	**0.48*** **	**0.46*** **	**0.47*** **
	(7.49)	(7.16)	(28.53)
$\Delta EMPshare(L2)$	-0.09	-0.07	-0.08
	(-1.32)	(-1.14)	(-1.37)
slavex	0.87	0.88	-2.79
	(1.14)	(1.13)	(-1.51)
colyears	3.12	3.03	-7.99
	(0.64)	(0.61)	(-0.60)
distance	**-4.82***	**-4.89***	-9.11
	(-2.11)	(-2.10)	(-1.32)
rainfall	**-11.37*** **	**-11.40*** **	**-11.45** **
	(-3.41)	(-3.42)	(-3.15)
gdppc	-30.46	-31.05	-3.37
	(-0.93)	(-0.93)	(-0.08)
$gdppc^2$	2.74	2.79	1.05
	(1.28)	(1.28)	(0.41)
pop	**75.00*** **	**76.31*** **	34.83
	(2.97)	(2.96)	(0.97)
pop^2	**-2.10*** **	**-2.14*** **	-0.73
	(-2.86)	(-2.86)	(-0.69)
china	**-1.43***	**-1.44***	**-1.98** **
	(-1.71)	(-1.70)	(-2.13)
hightecx	0.88	0.87	1.14
	(1.35)	(1.33)	(1.59)
human	7.93	7.88	-12.6
	(1.24)	(1.21)	(-1.15)
FDI	0.39	0.40	**0.60** **
	(1.51)	(1.52)	(2.17)
credit	**-5.31***	**-5.35***	**-7.23*** **
	(-2.29)	(-2.27)	(-2.74)
rural	**18.82***	**19.16***	0.34
	(2.54)	(2.54)	(0.02)
tfp	18.11	17.77	21.45
	(1.13)	(1.10)	(1.28)
digit	**-40.29*** **	**-40.57*** **	**-51.61** **
	(-4.71)	(-4.69)	(-2.50)
constant	**-489.1***	**-498.9***	-93.9
	(-2.11)	(-2.12)	(-0.29)
N	210	210	210
Wald chi^2	160.80	151.00	156.91
Prob > chi^2	0.00	0.00	0.00

t or z-statistics in parentheses, based on robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

However, this is not to say that the estimation strategy has resulted in the best possible estimates. There may still be omitted variables. We may be ignoring interaction effects amongst the independent variables. Where our results may be contrasting with that of other studies, explanations may be needed. To deal with these concerns we subjected our regression models to several robustness tests, which we discuss in this section.

4.3.1 Multiple estimators

The first robustness check we already reported on - this consisted of using multiple estimators to estimate equation (2). We identified a number of variables that were robustly significant according to all estimators used. This gives us some confidence before starting further robustness checks regarding the parameter stability of our approach.

In sum, our estimator-robust variables determining the share of MVA and share of employment in manufacturing (i.e. the long-run levels of industrialization) were the first-order lagged values of the respective shares, the number of years a country has been subject to colonial rule, annual rainfall, GDP per capita and its square, and the share of imports from China. For the growth rates (short-term fluctuations) in the MVA share and share of employment in manufacturing, the estimator-robust variables were rainfall, the lagged growth rate, the share of imports from China, credit extended to the private sector, and the extent of digital adoption.

In the sub-sections to follow, we try to evaluate whether we may be missing potentially significant variables, and attempt to compare our results with those of similar studies.

4.3.2 Omitted variables

We conducted a second set of robustness checks by adding various possible suspected variables to the regressions and evaluating their significant and the stability of the parameters. It allows us also to explore possible interaction effects amongst our variables and consider whether we have possible omitted variable bias.

The literature on growth and development in Africa, especially in sub-Saharan Africa, considers the role of factors including conflict, macro-economic conditions, general business and political uncertainty, the role of regional integration/ regional markets and import protection policies for manufacturing. We have alluded to this literature in section 2 of this paper. Of course, we can argue against including these possible determinants, because they may already be reflected in the variables that are included. GDP per capita, financial development (credit extended), urbanisation, and total factor productivity growth (to name but three) generally tend to be correlated with these - see e.g. McGillivray (1991)) and Henderson (2010). Institutional quality is often measured by indicators of financial development, GDP per capita. The effect of the slave trades, for instance, have been found to explain variance in trust across contemporary Africa, and trust is a form social capital that plays in role in conflict avoidance and resolution, rule of law, and investment behaviour.

However, to check the correctness of our assumptions and choices, we added these to our basic model, using the fractional logit estimator for the MVA share and employment share, and the FGLS for the growth rates.

The variables that we added to those used in Tables 3 and 4 are summarised in Table 7.

Table 7: Additional independent variables used for robustness checks

Variable	Description	Source
Violent conflict		
milexp	Military expenditure as % of GDP	World Bank, WDI online (series MS.MIL.XPND.GD.ZS)
Macro-economic stability		
inflation	Inflation, consumer prices (annual %)	World Bank, WDI online (series FP.CPI.TOTL.ZG)
Business and political uncertainty		
wui	World Uncertainty Index (WUI) measures of uncertainty for each SSA country in the sample	Ahir et al. (2022)
Regional markets		
afrx	Share of total exports to other African countries, % share	CEPII BACI HS96 revision Feb 2021
Industrial policies		
tariff	Share of tariff lines in the tariff schedule with tariff rates that exceed 15 percent, manufactured products (%)	World Bank GOVDATA360 (series TM.TAX.MANF.IP.ZS)

Source: Authors' own compilation.

The regression estimates using these additional variables are contained in Appendix B, Table 9. We can summarise these as follows, comparing columns (1) to (4) with Tables 3 to 6, respectively.[17]

[17] Although, for the sake of space limitation we do not show it, the lagged values of the dependent variables

First, we can see that in the case of the MVA share, none of the added variables are statistically significant. Rainfall, distance, and the share of the rural population, remain unaffected in terms of significance and sign. The number of years under colonial rule, GDP per capita and total factor productivity growth however lose their significance, and credit to the private sector becomes significant (and positive). We can conclude that these variables are sensitive to the addition of further variables. Second, in terms of the growth of the MVA share, rainfall remains statistically significant. Third, in case of the share of manufacturing in employment, the results are less sensitive to additional variables. Moreover, uncertainty in the external environment, as measured by the World Uncertainty Index (*wui*), as well as the number peak tariff lines, are both statistically significant with positive impacts on the employment share in manufacturing. The latter suggest a positive impact of import protection for manufacturing. We also note that tariff protection for manufacturing has a positive impact on growth in the share of employment in manufacturing. The former, however, may on the face of it present a puzzle, at least when seen from the lenses of firm-level studies where uncertainty leads to postponement of investment and hiring decisions. The question that thus arises is, why would uncertainty have a positive impact on employment in manufacturing?

Gong et al. (2021) in a study of uncertainty and manufacturing upgrading in China found that economic policy uncertainty had both positive and negative effects on manufacturing but in net was positively associated with structural upgrading in manufacturing. They found evidence that while uncertainty reduced employment of relatively more skilled labor, it also induced vertical integration and service transformation which countered this. We do not think that this is the case though for Africa. It may be rather be that employment in most African manufacturing firms are less affected by uncertainty, because, as Kruse et al. (2021, p.22) found most "employment industrialization in sub-Saharan Africa is driven by small firms." Diao et al. (2021) found similar evidence from Tanzania and Ethiopia. The small - and un-registered (thus informal) firms tend to employ low-skilled workers and are less dependent on financial sector development[18], FDI and foreign demand than larger formal firms. These small and informal manufacturing firms in Africa may be expanding employment by absorbing labor lost from larger formal (and insufficiently productive) manufacturing firms - acting as an employer of last resort. This would be consistent with the trends in the post-1990 MVA share and employment in manufacturing share as shown in Figure 1: increasing manufacturing employment accompanied by a declining MVA share.

are significant in all the columns of the Table 9 in Appendix B.

[18]Aghion et al. (2010) have shown that uncertainty typically has larger impacts on sectors that are more dependent on external finance.

Having summarised the results from adding additional variables to our basic regression as is contained in In Appendix B, Table 9, we can also mention that, in addition to adding all the additional variables simultaneously, we performed a further check by adding these sequentially (the results are available on request). When adding the variables sequentially to the MVA Share regressions, none were significant, and the results as in Appendix B, Table 9, did not change significantly.

In conclusion, our results are fairly robust to additional variables. Annual rainfall is the one variable that has been found to be robust, not only to the estimator used, but also towards the variables included in the model and for both MVA and employment shares and their growth rates. This is a rather novel finding - none of the recent studies concerned with African industrialization have considered rainfall. It is also consistent with our expectations based on our literature survey. Recall that in section 2 we highlighted two effects that can give rise to a negative relationship between rainfall and industrialization: the first was due to the fact that the tropics receives more rainfall than other latitudes, but that prospects for industrialization are more difficult in the tropics due to lower agricultural productivity, a greater disease burden and having had more extractive forms of colonialism. The second was due to the possible effects of climate change, whereby declining rainfall leads to urbanization towards cities wherein manufacturing plays a larger role (Henderson et al., 2017).

The results in Table 9 of Appendix B also suggested that specifying an identical model for the MVA share and the employment share in manufacturing may not be correct: while in the case of the MVA share none of the additional variables we added, whether simultaneously or sequentially, were significant. However in the case of the employment share in manufacturing we found that additional variables such as military expenditure, uncertainty, the share of exports destined for other African countries, and the share of tariff spikes on manufactured products may - perhaps not robustly - be significant. Taking into account differences in productivity levels and trends between manufacturing and other sectors, the shares of manufacturing in employment and in GDP are thus measuring different dimensions of industrialisation, which do not have a uniform set of determinants.

4.3.3 Re-estimating manufacturing growth

Considering the core results in tables 3 to 6, our model performs relatively poorly in explaining the growth rate of the MVA share, and to a lesser extent that of the growth rate of the employment share in manufacturing. Even adding additional variables as explained in the previous sub-section, have not improved the explanatory power of our manufacturing growth specifications significantly. While, as we already mentioned it is typically more difficult to predict short-term changes in a variable such as an annual growth rate, especially using structural rather than time-series specifications, we are concerned that given the nature of variable denoted in growth rates, its variance may make our estimators not ideal to identify the relationship amongst the variables. We therefore used additional estimation strategies to re-estimate our manufacturing growth models (as reported in Tables 4 and 6).

First, we utilised a quantile regression (QR) model. This is because there are quite a number of outliers in the growth rates of these dependent variables. For example, as Table 8 in Appendix A shows, the MVA share growth rate in our sample ranges from -44% to 98% and the growth rate of the share of employment in manufacturing ranges from -45% to 193%. In such cases, typical estimators that specifies the average relationship amongst variables, are likely to fare less well in the presence of such outliers.

A quantile regression model allows estimation of the conditional median relationship between variables, as well as the relationship over different intervals (e.g. quantiles, quintiles or deciles) (Koenker and Hallock, 2001). This approach is potentially helpful in the present case if the determinants of the growth rates of our industrialization variables are different between slow and faster industrializers - i.e. industrializers with MVA share and employment share growth rates at the lower (0.1) and upper (0.9) quantiles of the distribution. In such cases it may not be optimal to focus on the average case.

Second, we focused on only those countries in the sample for those periods in which the managed to growth *both* MVA share and the employment share in manufacturing. Recall that industrialization (deindustrialization) would require both the MVA share and the share of employment in manufacturing so increase (decrease) simultaneously. We are interested in identify the determinants of such simultaneous growth. To do this, we created a dummy variable which = 1 if in a particular year a country had positive growth in both the MVA share and the employment share, and =0 if otherwise. We utilised a logistic (logit) regression model with the independent variables as listed in Table 2.

Our QR[19] and logit model results are contained in Appendix C, in Tables 10, 11 and 12 respectively. Table 10 in Appendix C shows that determinants of the lower-and-upper quantile growth rates are indeed quite different. GDP per capita and its square (market size) are significant determinants of countries with MVA share growth in the lower quantile of

[19]The lagged dependent variables are not included in the QR since it does not allow time-series operators.

the distribution. It is insignificant for countries in the higher quantile of the distribution. The determinants of fast MVA share growth are elusive - none of our variables of choice are significant as far as short-term high-growth in MVA share is concerned.

Table 11 in Appendix C shows that our variables are more meaningful to help explain growth in the employment share in manufacturing. This growth in the lower (0.1) quantile is determined my much of the same determinants that drive growth in the average case, as comparison with the FGLS estimates in column (1) show. Noticeable though, rainfall and the share of the population in rural areas are not significant in either the low and upper quantiles of growth. Given the very robustness that the annual rainfall had so far shown as a determinant of both the longer and short term shares of manufacturing, it is interesting that at least as far as the effect on growth is concerned, it is a average effect across countries, that is not driving either fast or slow manufacturing growth.

The positive coefficient on the extent of slave exports and the negative coefficient on GDP per capita in the upper quantile case is consistent with the earlier finding of convergence in employment share growth: amongst the countries with the employment share in manufacturing growing fastest are those with low GDP per capita and higher numbers of people exported as slaves between 1400 and 1900. The sign on credit extended changes - from negative in the average case, to positive in the upper quantile case. This suggests that financial development do matter positively for the growth in the employment share for those countries that achieved fast growth in the share over the period.

Table 12 in Appendix C contains the results from estimating the determinants of simultaneous growth in the MVA and employment shares, as recorded by a dichotomous dependent variable that is equal to one if in a particular year both MVA share and employment share had positive growth - consistent with industrialization. Out of the 972 observations that we have over the period 1965 to 2018, there were 262 occurrences of simultaneous growth. These results show the probabilities that certain variables will be associated with this outcome of simultaneous growth in the MVA and employment shares.

Because we have panel data, and thus the possibility that the observations are not independent,[20] we first estimated our dichotomous dependent variable by both a random-effects (RE) and conditional fixed-effects (FE) model using the logistical estimator (which uses the cumulative distribution function of the logistic distribution).

[20]Post-estimation a LR-test could not reject the null hypothesis that the parameter ρ is equal to zero, hence the intra-panel correlation is not significant, meaning a standard logit model could just as well be be fitted

As can be seen from Table 12 in Appendix C, rainfall has - again - a negative and statistically significant effect on the probability that both indicators of industrialization experience simultaneous growth. This result is robust across the random-effects (RE) and conditional fixed-effects (FE) models. Furthermore, the share of high-tech manufacturing exports and the extent of credit extended to the private sector are significantly in the RE specification. Once we control for the share of exports to other African countries, and the number of tariff peaks as proxy for (protectionist) industrial policy measures, these two variables become insignificant, and total factor productivity growth (tfp) becomes significant, the sign of its coefficient indicating that technological innovation / productivity growth will reduce the probability that a country will achieve growth in both MVA share and employment share simultaneously. We have already established that total factor productivity growth has a negative impact on the growth of the MVA share (Table 5) and the share of employment in manufacturing (Table 4). Controlling for country fixed effects, the results in columns 3 and 4 of Table 12 (Appendix C) shows that countries with better human capital significantly raises the probability that they will achieve growth in both the MVA and employment share in manufacturing at the same time.

4.3.4 Comparison with the Literature

Our fourth approach to scrutinize our results is to compare it to the results from comparable recent studies. In making the comparisons we should be careful however, given that estimation methods, data, time periods and variables used differ. It is no surprise that different empirical studies all find somewhat different results. What is potentially most valuable from making comparisons is where such quite different methods result in comparable findings, and to be able to explain significant differences.

Four recent studies closest to ours are those of Mensah (2020) Nguimkeu and Zeufack (2019), Kruse et al. (2021) and Tregenna et al. (2021). Mensah (2020) estimated the determinants of the share of manufacturing employment in a sample of 18 SSA countries over the period 1970 to 2015. His independent variables were population and GDP per capita and their squares (to capture non-linear effects). To measure the effect of technology he included a measure of the relative productivity growth in manufacturing, and to reflect the ability of an economy to respond to consumers both domestic and abroad, added measures of international trade (exports and imports of manufactured goods), fixed and human capital, and FDI inflows. Macroeconomic stability was measured by using a measure of real exchange rate overvaluation. Overall, there is thus a broad overlap between the variables used by Mensah

(2020) and by our own study - we use slightly different and sharper measures for trade and human capital. The most notable difference perhaps is that our study also included measures of financial development, geography and historical legacies, which is not only neglected by Mensah (2020), but has typically been neglected in the industrialization literature so far.

From his results (see his table 5 of Mensah (2020, p.25)) he established that population growth is significant and with signs as expected - i.e., population growth is up to a point positively associated with the manufacturing share of employment, after which the relationship turns negative. This indicates that the domestic market size matters. We established a similar relation with the levels of population, and also with GDP per capita. Thus, our study concurs with Mensah (2020) about the importance of domestic market size for industrialization in Africa.

Mensah (2020) furthermore found that FDI can reduce[21] manufacturing employment (particularly when human capital is lacking). In contrast, FDI was insignificant in all our estimations, except in our systems dynamic panel data estimator of the growth rate in the manufacturing employment share. Mensah (2020) furthermore found a negative effect from imports from other developing countries outside Africa, which is consistent with our robust finding of a negative effect of imports from China on the growth rate of the share of employment in manufacturing and the longer-term shares of employment in manufacturing and the MVA share.

The major difference between our findings and that of Mensah (2020) is that he found that GDP per capita does not have an inverse U-shape relationship with manufacturing's employment share, as we did. As a consequence, Mensah (2020) reports not finding any evidence of (premature) deindustrialization in Africa generally although he does not find evidence of industrialization either, concluding that " [...] we observe no significant industrial change" (Ibid, p.2). He does however find regional differences within Africa, with "East Africa industrializing and Southern Africa deindustrializing" (Mensah, 2020, p.2). To control for the possibility that deindustrialization in the Southern African region may dominate our results, we included a dummy variable = 1 if a country was in Southern Africa, and =0 if otherwise. This found that the dummy is indeed statistically significant and negative. However, the significance of GDP per capita and its square did not change. Therefore, our finding of (premature) industrialization is robust and more general than the Southern Africa region.

[21] Other studies that have found a negative relationship between industrialization and FDI in Africa include Kaya (2010) and Müller (2021). The reason given is that most FDI aims at natural resource exploitation, not manufacturing.

A second study close to ours is by Nguimkeu and Zeufack (2019). They used various data sources, including the GGDC, EASD as well as the World Bank's Development Indicators (WDI) and others, to construct an unbalanced panel of 41 Sub-Sahara Africa countries covering 1960 to 2016. They also employed a fixed effects fractional logit model to estimate the share of manufacturing in GDP and employment in Sub-Saharan Africa as a function of GDP per capita, GDP per capita squared, and various control variables in order examine whether there has been premature deindustrialization. They concluded that "deindustrialization does not appear to be the common experience of the majority of Sub-Saharan African countries. Only the Southern SSA subregion appears to have deindustrialized over the period under study" (Nguimkeu and Zeufack, 2019, pp.24-25).

A third study close to ours is that of Kruse et al. (2021). They used the Economic Transformation Database (ETD) which covers 51 countries, 18 in SSA, over the period 1990 to 2018. Performing roughly similar regression analyses[22] as Rodrik (2016), Nguimkeu and Zeufack (2019) and Mensah (2020), Kruse et al. (2021, p.25,2) concluded that " We confirm that de-industrialization was widespread until the early 2000s" and that "when we use the same set of countries as in Rodrik (2016), we do not find industrialization, but the larger sample of African countries in the ETD indicates a significant industrialization trend." Rodrik (2016) used a sample of 11 African countries. Kruse et al. (2021) confirmed that in this sample Rodrik (2016)'s result holds and that de-industrialization was "widespread" until 2000. But when seven more countries are added, this result is somehow reversed. They did not include any controls in their regression analyses, except for time and regional dummy variables. And they consider only the period 1990 to 2018 - considerably shorter that the periods used in our paper, and by Nguimkeu and Zeufack (2019), who found a more nuanced answer to the question whether SSA is deindustrializing or not.

Finally, a fourth study that comes close in spirit to ours, is that of Tregenna et al. (2021) - with the major difference that they are not exclusively concerned with Sub-Saharan Africa, but focus on a sample of 99 countries, and do so over the period 1991 to 2014 - thus a comparatively short (er) period that Mensah (2020) or the present paper. Bearing these differences in mind, their key findings are as follows.

Firstly they found that there is a significant inverted U-shape relationship between GDP per capita and industrialization for their whole sample. This finding is similar to ours in the case of Africa.

[22] They use an OLS FE estimator to estimate an model similar to our equation (2). Whether this is the best estimator for use, given our discussion, is perhaps a concern.

Second, they found that human capital is negatively associated with manufacturing in Sub-Saharan Africa, concluding that human capital development leads to faster growth in the shares of non-manufacturing sectors. This finding is in contrast with our finding that human capital is positively associated with the MVA share, and moreover with growth in the share of employment in manufacturing (specifically of fast-growth in the upper quantile) and the probability of achieving simultaneous growth in the MVA share and share of employment. Rather, we found that technological innovation and digital adoption are negatively associated with manufacturing - given that Tregenna et al. (2021) did not control for these, it may be that their human capital variable picks up on technological ability.

Third, Tregenna et al. (2021) found that evidence of an inverted U-curve relationship between population size and manufacturing employment shares, which indicates that market size matter up to a point. While their finding is based on a Western European sub-sample, we confirmed this finding in the case of Africa - when using a systems dynamic panel data estimator (see Table 4).

An important point that Tregenna et al. (2021) make is to point out that they found it difficult to identify consistent and robust determinants for their total sample, concluding that more dis-aggregated analyses are needed, such as focusing on particular regions and countries. This finding provides not only support for our approach that focuses on a sample of only (18) Sub-Saharan African countries but also for our approach of including a broad spectrum of variables, including geographical and historical legacy variables, which none of the recent studies closest to ours have considered. If, as Tregenna et al. (2021) argue for a more regionally dis-aggregated analyses, then it is imperative to include specific features characterising that region. In the case of Sub-Saharan Africa, its unique history and geography cannot therefore, be left out of any consideration of the empirical determinants of industrialization.

5 Summary, Conclusions and Prospects

In this paper, we attempted to identify the determinants of industrialization in 18 African countries, 1965 to 2018, using FGLS, system dynamic panel data, fractional logit, logit, and quantile regression estimators. In addition to using a variety of estimators, we subjected our results to various robustness checks.

We established that industrialization in Africa is driven by historical legacies such as colonialism; geographical factors such as rainfall and distance from international markets; economic factors such competition from China, market size and urbanization; and technological factors such as digital technology adoption. An inverse U-shape relationship between industrialization and GDP per capita is consistent with (premature) de-industrialization.

We highlighted the finding that annual rainfall has a robust and negative impact on both MVA and employment shares and their growth rates. This is a rather novel finding - none of the recent studies concerned with African industrialization considered rainfall. The negative relationship between rainfall and industrialization may be for two reasons: one is that the tropics receives more rainfall than other latitudes, but that prospects for industrialization are more difficult in the tropics due to lower agricultural productivity, a greater disease burden and having had more extractive forms of colonialism. A second is due to the possible effects of climate change, whereby declining rainfall has been found elsewhere to lead to urbanization, where manufacturing plays a larger role.

Furthermore, our results indicate that while the level and pace of industrialization have many common determinants, there are also important differences - for instance while lack of urbanisation (a larger rural population) seems to hinder the MVA share and its growth, it does drive short-term, annual growth rates in employment in manufacturing. Somewhat similar, the extent of financial development (measured by credit extended to the private sector) tends to insignificant except in the case of growth in the employment share, where countries with a comparative lack of financial development experience faster growth. These suggest a catch-up effect.

Given that our technological variables (e.g. the share of high-tech exports, total factor productivity growth and the digital adoption index) were either statistically insignificant, or when significant had a negative coefficient, the implication is that technological change has an ambiguous relationship with industrialisation in Africa. This is in line with the expectations of (Hallward-Driemeier and Nayyar, 2018). Moreover, if technology becomes more important in future to sustain and maintain GDP growth, then even a lack of such technology will put a brake on African industrialization. Hence both rapid adoption of technology *and* the digital divide (lack of adoption) may hinder industrialization in Africa.

The establishment of the AfCFTA is timely, as it would provide for larger market size, could potentially reduce the burden of distance to the coast for landlocked countries, and raise competitiveness against Chinese imports. The benefits of AfCFTA will however only be realised if countries also improve infrastructure to overcome the negative consequences of adverse geography (large distances, also to foreign markets), improve trade facilitation to exploit learning-by-exporting from intra-African trade, facilitate urbanization and navigate the fragmenting global geopolitical order.

Our paper did not consider the continued relevance of manufacturing for structural transformation and growth in Africa. This is an important topic - pressing for industrialization is moot if manufacturing is not anymore (or the best) engine of productivity growth. As far as we can discern, the current evidence seem to tilt slightly in favor of manufacturing still being important for Africa. More generally in developing countries this does not seem to be the case, however. Herrendorf et al. (2022) created a dataset of comparable labor productivity levels in agriculture and manufacturing for 64 countries spanning the period 1990 to 2018. They concluded that this data rejects the thesis that manufacturing is an engine of development - as such they conclude that "conditional on workers moving out of agriculture, aggregate gaps would decrease by more if the workers relocated to a sector other than manufacturing" (Herrendorf et al., 2022, p.1). Thus, expanding manufacturing employment in developing countries may not lead to productivity enhancing structural change. The findings of McMillan and Zeufack (2022) which focuses on Africa suggests that this is perhaps not (yet) relevant for Africa, which is also in line with the findings of Haraguchi et al. (2017), who makes a strong case that manufacturing still matters.

Where there is premature deindustrialization in Africa this seems, based on our empirical evidence, to be driven by a negative trade effect (imports from China) which reduces any comparative advantage (low-skilled labor) further, supply-side factors, such as technology and rainfall which shapes the relative costs and benefits of manufacturing vis-a-vis agriculture and services, and demand-side factors such as distance from world markets and a largely rural population. In light of this, recent global developments are troubling.

The split of the global economy into a "Western zone and a Chinese zone" (Brooks, 2022, p.1), disruptions in supply chains (Katsaliaki et al., 2021), the rise of digital platform capitalism (Naudé, 2023), the return of explicit strategic trade policies in many advanced economies in response to COVID-19 (Bown, 2021; Dean et al., 2021; McCann et al., 2021) and to facilitate the energy transition / green economic growth (Johnson, 2023; EC, 2023; Yergin, 2022), and more sluggish global growth due to the war in Ukraine and rising energy and food prices (Guénette et al., 2022), are further obstacles. Moreover, de-globalization coupled with declining and ageing population in Europe and China are may be raising the spectre of a new scramble for Africa: "its low level of industrialization means it has far more industrial commodities than it could ever use ... and that *will* attract outsiders" (Zeihan, 2022, p.158).

All of these factors will make industrialization more difficult. Strategic industrial policy - that can best leverage the continent's substantial latent assets[23] - ought to be a priority on the African development agenda.

[23] Henn and Robinson (2021) makes the observation that African societies have three types of latent assets: talent-driven success, skepticism of authority, and cosmopolitanism. These will support entrepreneurship and innovation, stronger institutions, and globalization.

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Appendices

Appendix A: Descriptive Statistics

Table 8: Summary of variables

Variable	Observations	Mean	St. Dev.	Min	Max
Dependent					
MVAshare	955	10.9%	5.1%	0.46%	26.4%
EMPshare	937	6.5%	5.5%	5.8%	31.5%
MVA growth	937	1.6%	9.7%	-44%	98%
EMP growth	920	2.0%	12.5%	-45%	193%
Independent					
slavex	972	394,569.7	617,862.2	0	2,021,859
dist	972	469	268	6	946
colyears	972	135	104	15	406
rainfall	972	947	412	129	3089
credit	843	18.60	17.46	1.10	106.26
FDI	802	2.10	3.38	-10.77	39.46
afrx	398	23.69	14.09	0.01	60.3
hightecx	398	4.73	5.34	.05	30.56
tfp	727	0.23	4.9	-63.3	29.4
gdppc	522	4,187.94	4,366.36	436.72	22,208.14
inflation	796	12.18	16.45	-9.08	183.3
human	972	0.43	0.26	0.00	1.06
wui	893	136.87	161.4	0	1343
china	437	7.36	8.29	0	69.3
digit	972	36.38	10.66	23	61
rural	972	72.94	15.49	30.55	97.11
milexp	851	2.08	1.63	.14	10.32
tariff	315	37.06	15.15	2.19	89.5
pop	972	20,692,710.5	28,401,341.6	559,994	195,874,740.0

Authors' calculations.

Appendix B: Robustness Checks - Additional Variables

Table 9: Robustness Check : Variable Sensitivity

	(1) MVA Share	(2) ΔMVA Share	(3) EMP Share	(4) ΔEMP Share
lags	YES	YES	YES	YES
slavex	-0.01	-0.65	0.00	1.64
	(-0.88)	(-0.49)	(1.37)	(1.62)
colyears	**0.21****	1.01	**0.10****	**13.87***
	(2.30)	(0.11)	(2.40)	(2.03)
distance	**-0.11****	-2.11	-0.00	0.00
	(-2.37)	(-0.44)	(-0.01)	(-0.00)
rainfall	**-0.09***	**-10.28***	**-0.17*****	**-16.94*****
	(-1.81)	(-1.89)	(-3.66)	(-4.26)
gdppc	0.80	28.50	0.01	-26.70
	(1.39)	(0.44)	(0.22)	(-0.56)
$gdppc^2$	-0.06	-2.48	-0.00	2.59
	(-1.50)	(-0.59)	(-0.06)	(0.83)
pop	0.16	-18.24	0.04	70.49*
	(0.34)	(-0.35)	(1.39)	(1.80)
pop^2	-0.00	0.62	-0.00	**-1.98***
	(-0.30)	(0.40)	(-1.34)	(-1.74)
china	-0.01	0.12	-0.00	-1.39
	(-0.66)	(0.08)	(-1.10)	(-1.22)
hightecx	-0.01	-0.45	0.00	1.20
	(-0.63)	(-0.36)	(1.36)	(1.30)
human	0.13	9.45	0.01	14.35
	(1.23)	(0.80)	(1.79)	(1.65)
FDI	0.00	0.19	**0.00***	**0.63***
	(0.60)	(0.47)	(1.84)	(2.13)
credit	0.01	2.42	-0.00	-4.62
	(0.35)	(0.62)	(-0.06)	(-1.59)
rural	-0.16	-19.35	0.01	**18.39***
	(-1.29)	(-1.37)	(1.51)	(1.77)
tfp	-0.19	-17.87	0.01	10.28
	(-0.82)	(-0.68)	(0.88)	(0.53)
digit	**-0.27***	-10.35	**-0.03*****	**-57.99*****
	(-2.04)	(-0.75)	(-4.66)	(-5.62)
milexp	-0.01	-3.66	-0.00	-2.67
	(-0.33)	(-0.95)	(–0.49)	(-0.94)
wui	0.00	0.52	0.00	-0.28
	(0.15)	(0.53)	(0.22)	(-0.39)
inflation	-0.00	-0.08	-0.00	-0.08
	(-0.81)	(-0.75)	(-0.32)	(-0.92)
afrx	-0.01	-1.08	0.00	1.83
	(-0.49)	(-0.51)	(0.44)	(1.13)
tariff	-0.01	-0.59	**0.01*****	**8.97****
	(-0.31)	(-0.14)	(3.26)	(2.93)
constant	-3.64	246.23	-0.43	-463.47
N	154	154	154	154

z-statistics in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix C: Robustness Checks - Additional Growth Estimates

Table 10: Quantile regression results : Dependent variable Growth rate of the MVA share

	(1) FGLS	(2) Quantile (0.1)	(3) Quantile (0.9)
slavex	-0.28	-2.44	0.87
	(-0.31)	(-1.49))	(0.25)
colyears	1.37	14.68	1.63
	(0.23)	(1.37)	(0.07)
distance	-1.88	-2.68	2.24
	(-0.68)	(-0.53)	(0.21)
rainfall	**-7.29***	-10.16	-11.37
	(-1.80)	(-1.38)	(-0.74)
gdppc	5.34	**140.25***	-54.74
	(0.14)	(1.97)	(-0.37)
$gdppc^2$	-0.82	**-9.93***	3.10
	(-0.32)	(-2.14)	(0.32)
pop	-19.12	-38.7	-24.11
	(-0.62)	(-0.70)	(-0.21)
pop^2	0.65	1.24	0.85
	(0.73)	(0.77)	(0.25)
china	-0.53	1.21	-2.89
	(-0.54)	(0.67)	(-0.78)
hightecx	-0.17	-1.15	1.17
	(-0.23)	(-0.81)	(0.40)
human	6.15	-0.01	9.62
	(0.80)	(-0.00)	(0.33)
FDI	0.21	0.80	-0.19
	(0.63)	(1.39)	(-0.16)
credit	0.29	-2.38	3.89
	(0.10)	(-0.47)	(0.37)
rural	-13.64	-22.07	-10.58
	(-1.52)	(-1.35)	(-0.31)
tfp	-27.77	-13.38	0.11
	(-1.42)	(-0.38)	(0.00)
digit	-8.40	2.89	-40.09
	(-0.84)	(0.16)	(-1.06)
constant	273.2	-63.61	616.03
	(0.97)	(-0.12)	(0.58)
N	210	210	210
		Pseudo $R^2 = 0.22$	Pseudo $R^2 = 0.15$

t or z-statistics in parentheses, based on robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: Quantile regression results : Dependent variable Growth rate of the share of employment in manufacturing

	(1) FGLS	(2) Quantile (0.1)	(3) Quantile (0.9)
slavex	**1.77***	1.23	**6.33*****
	(2.11)	(0.96)	(3.85)
colyears	3.39	8.77	-10.34
	(0.62)	(1.04)	(-0.96)
distance	**-5.10***	**-8.71****	7.75
	(-1.98)	(-2.20)	(1.53)
rainfall	**-13.94*****	-9.54	-6.79
	(-3.71)	(-1.65)	(-0.92)
gdppc	-59.49	-47.38	**-291.29*****
	(-1.64)	(-0.85)	(-4.09)
$gdppc^2$	**4.84***	3.49	**18.92*****
	(2.04)	(0.960)	(4.07)
pop	**99.02*****	**75.51***	66.63
	(3.48)	(1.73)	(1.20)
pop^2	**-2.80*****	-2.06	-2.03
	(-3.39)	(-1.63)	(-1.25)
china	**-2.48*****	**-2.49***	**-6.38*****
	(-2.70)	(-1.78)	(-3.56)
hightecx	**1.51***	1.29	1.86
	(2.08)	(1.16)	(1.31)
human	11.54	16.67	**24.37***
	(1.61)	(1.52)	(1.74)
FDI	0.28	0.30	-0.19
	(0.94)	(0.66)	(-0.33)
credit	**-5.29***	-3.04	**9.29***
	(-2.05)	(-0.77)	(1.83)
rural	**25.04*****	18.35	2.52
	(3.00)	(1.44)	(0.15)
tfp	13.14	-8.95	17.35
	(0.72)	(-0.32)	(0.49)
digit	**-56.04*****	**-48.62*****	**-49.36****
	(-6.01)	(-3.40)	(-2.70)
constant	**-573.0****	-458.95	693.55
	(-2.19)	(-1.15)	(1.36)
N	210	210	210
		Pseudo $R^2 = 0.28$	Pseudo $R^2 = 0.35$

t or z-statistics in parentheses, based on robust standard errors
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: Logistical regression estimates: dependent variable = 1 if simultaneous growth in MVA share and employment share, = 0 otherwise

	(1) RE	(2) RE	(3) FE	(4) FE
slavex	0.37	0.41	-	-
	(1.02)	(0.90)		
colyears	2.04	1.71	-	-
	(0.86)	(0.56)		-
distance	-0.24	0.57	-	-
	(-0.22)	(0.33)		-
rainfall	**-3.76***	**-4.02***	**-4.09***	**-4.20***
	(-2.17)	(-1.89)	(-2.09)	(-1.85)
gdppc	-1.56	1.78	-30.66	25.04
	(-0.10)	(0.08)	(-0.77)	(0.35)
$gdppc^2$	0.07	-0.18	1.73	-1.81
	(0.07)	(-0.12)	(0.70)	(-0.42)
pop	-0.07	-4.29	9.54	7.33
	(-0.01)	(-0.22)	(0.35)	(0.20)
pop^2	-0.00	0.13	-0.44	-0.49
	(-0.01)	(-0.23)	(-0.51)	(-0.41)
china	0.12	0.11	0.34	0.39
	(0.31)	(-0.20)	(0.53)	(0.44)
hightecx	**0.53***	0.19	**0.65***	0.33
	(1.68)	(0.48)	(1.74)	(0.67)
human	4.33	3.56	**29.33***	**37.82***
	(1.34)	(0.82)	(2.31)	(1.94)
FDI	-0.15	-0.13	-0.15	-0.13
	(-1.12)	(-0.86)	(-1.07)	(-0.74)
credit	**-2.42***	-2.31	-1.87	-2.57
	(2.21)	(-1.64)	(-1.47)	(-1.43)
rural	0.03	-4.11	17.45	4.72
	(0.01)	(-0.81)	(1.40)	(0.27)
tfp	-7.65	**-16.71***	-9.43	**-15.86***
	(-0.97)	(-1.76)	(-0.06)	(-1.69)
digit	-5.53	-3.75	-	-
	(-1.29)	(-0.75)		
afrx		0.97		0.68
		(1.04)		(0.64)
tariff		0.25		1.38
		(0.17)		(0.84)
constant	38.77	75.87	-	-
N	210	210	210	210
Wald chi^2	21.20	18.98	21.94	19.07
Prob > chi^2	0.17	0.3930	0.038	0.1622

z-statistics in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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