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Agricultural Productivity and Industrialisation in Africa: There Is a Link?

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Abstract
The chapter examines the empirical relationship between the developments of agricultural productivity and industrialisation. We test the hypothesis of Matsuyama according to which agricultural productivity negatively affects industrialisation in a closed economy and negatively in an open economy. We adopted Pooled Mean Group methodology to account for both short and long run effect. We used aggregate data of industrial growth and agricultural labour productivity of 17 African countries over 1991-2022 period and established a negative relationship between these variables. Our findings show also that trade openness and domestic market contribute to industrial development.
Keyword*: Agricultural productivity, industrialisation, Africa, Pooled Mean Group*

Résumé
Ce chapitre examine la relation empirique entre l'évolution de la productivité agricole et l'industrialisation. Nous testons l'hypothèse de Matsuyama selon laquelle la productivité agricole affecte négativement l'industrialisation dans une économie fermée et négativement dans une économie ouverte. Nous avons adopté la méthodologie du Pooled Mean Group pour tenir compte des effets à court et à long terme. Nous avons utilisé des données agrégées sur la croissance industrielle et la productivité du travail agricole de 17 pays africains sur la période 1991-2022 et avons établi une relation négative entre ces variables. Nos résultats montrent également que l'ouverture commerciale et le marché intérieur contribuent au développement industriel.
Mot-clé : *Productivité agricole, industrialisation, Afrique, Pooled Mean Group*

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I.Introduction

The debate whether a country should develop its agricultural sector before embarking on industrialisation road have received greater attention in development literature. Overall, theoretically, whether agricultural development, in particular, agricultural productivity is a precondition to industrialisation dependent on whether countries are closed or opened to international trade.

In a closed economy, agricultural productivity is considered as main engine of industrial take off. The basic idea behind this proposition was that agricultural productivity growth would, in a closed economy, simultaneously lead to higher rural incomes, lower food prices in urban areas, increase savings in rural areas, mobilization of capital for domestic industry, and expand domestic markets for non-agricultural goods.

Several authors have recognised this driving role of agricultural sector (Johnson and Mellor, 1961; Rostow, 1960) and concluded that economic policies ought to favour agriculture for stimulating growth in developing economies such as those of Africa. Gollin, et al. (2002) argued that agricultural productivity is the key to understanding the timing of the shift from an agrarian based to an industrially based society. According to that literature, economic development follows a sequence, agricultural development first and then industrialisation.

However, another strand of the literature argues that agricultural productivity is not binding constraints of industrialisation for open economies. An open economy can easily overcome size market constraint, since it can export. It can also import food as well as all equipment needed for industrialisation. consequently, the requirement for agricultural development is not as binding as in a close economy (Shultz, 1964). Matsuyama (1992) and Duranton (1998) shown that as soon as countries participate to international trade, agricultural productivity is no longer necessary nor sufficient condition for industrialisation. In fact, they show that in an open economy, agricultural productivity may hinder industrialisation, and a country may industrialise at the low level of agricultural productivity.

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Despite the heated debate whether agricultural development is a necessary condition for industrialisation, relative few empirical evidences has been carried out. While Foster et Rosenzweig (2004) found a negative relation between employment in manufacturing sector and growth in the agricultural productivity, Bustos, Caprettini et Ponticelli (2016) showed that labour-saving productivity in agriculture sector led to industrial growth in Brazil.

The current paper aims to fill this gap by providing empirical evidence of the effect of agricultural productivity on industrialisation in Africa. In this paper, we investigate the effect of agricultural productivity on industrialisation in Africa for a period ranging from 1991 to 2022. Our empirical methodology is based on the pooled mean group approach. In our knowledge, the question we treated in this paper was not fully examined for the Africa case. Moreover, research on this issue is crucial as it could help policymakers to better understand the potential impact of investment in agriculture on the economy as a whole. Thus, policy decisions on resource allocations could be improved.

The rest of this paper is organized as follows: section 2 reviews the main literature. Section 4 and Section 5 present and discuss our empirical methodology and results, respectively. Section 6 concludes.

II. Literature review

While the classical models[2] of structural transformation predicted a positive relationship between agricultural productivity and industrialisation in closed economies, going from agriculture to industry, modern approach proposed by Matsuyama (1992) argues that agricultural productivity is not a sufficient condition for industrialisation in the case of an open economies. This latter approach points out that agricultural productivity may even undermine industrialisation in an open economy, as countries would specialise in agriculture at the expense of industry.

On the other hand, some authors increasingly have raised the causality issues between agricultural productivity and industrialisation (Gardner, 2003), showing that it is possible to have bidirectional causality. In other words, agricultural development would lead to industrial development, and vice versa.

2.1 Agricultural productivity and industrialisation in a closed economy: Importance of agricultural productivity to speed up industrialisation

For development economists, such as Lewis (1954) and Rostow (1960), countries have to move from agrarian economy to industrial one to be able to sustain economic growth and development. Agricultural development is perceived as an essential factor to structural transformation. According to traditional development theories, agricultural productivity fosters industrial development in closed economy through demand and supply channels.

The demand channel emphasises on the role of agricultural productivity in enlarging market demand for manufacturing goods. Indeed, in the literature about industrialisation, a small market size can be biding constraint to industrial take off because of fixed costs that characterised that sector. Agricultural productivity growth raises income per capita of farmers, which in turn generates demand for manufacturing goods as soon as preferences are not homothetic (Engel's law). The higher relative demand for manufactures generates a reallocation of labour away from agriculture in the structural transformation model (Murphy, Shleifer, and Vishny, 1989; Gollin, Parente, and Rogerson, 2002).

Murphy and al. (1989) demonstrate that an increase in agricultural productivity is necessary for initiation and continuation of the growth process. Using a big push model, they explain their result primarily by the assumption of increasing return to scale in manufacturing sector, due to high fixed cost, which imply that the size of the market for industrial goods determines whether the sector can operate profitably. Thus, rising income of farmers was seen as vital to provide a market for domestic manufactured goods and services (Adelman, 1984; Murphy et al., 1989). That result has been put ahead to support the design of agricultural-led industrialisation strategies, which stress the importance of agricultural sector development in creating a market for industrial products (Adelman, 1995).

Gollin, Parente, & Rogerson (2002) calibrate a two-sector growth model to demonstrate that a one-time increase in agricultural productivity can have dramatic consequences for the speed of country's economic development, they also identify agricultural productivity as key determinant of underdevelopment.

Johnston & Mellor (1961) argue that agriculture affects industrial development through demand and supply channels. According to Johnston and Mellor (1961), agriculture contribute to industrial development through enlarging market for industrial product, release labour to industrial work, supplying cheap foods to non-agricultural sector, producing raw materials for industrial processing, earning foreign exchange to facilitate import

[2] For example, Nurkse (1953) argued, "everyone knows that the spectacular industrial revolution would not have been possible without the agricultural revolution that preceded it" [p.52]. For Rostow (1960) "revolutionary changes in agricultural productivity are essential condition for successful take-off" [p.8].

capital and raise savings. As they claimed, "it is our contention that "balance growth" is need in the sense of simultaneous efforts to promote agricultural and industrial development. We recognize that there are sever limitation on the capacity of an underdevelopment country to do everything at once. But it is precisely this consideration which underscore the importance of developing agriculture in such a way as to both minimise its demand on resource most needed for industrial development and maximise its net contribution required for general growth" Johnston and Mellor (1961, pp 590-591).

Schultz (1964) and Hayami and Ruttan (1985) show that for developing countries, it may difficult to industrialise without making strong progress agricultural productivity. They recognised that traditional agriculture could be transformed rapidly into modern sector through adoption of science-based technology, thereby making the large contribution to industrial sector. Thus, for developing countries the primarily objective would be to stimulate green revolution, which afterward would sustain industrial development. Therefore, fight food insecurity has been among main objective of many Asian countries.

Gollin et al. (2007) evaluated the effect of food problem and the importance of modern agricultural technology on long run growth. They explained the effects of using three type of agricultural technology to calibrate the experience of United Kingdom over the last 200 years. In addition to the tradition technology, they consider two modern technologies: one is purely technical with an exogenous technology progress and does not use capital or manufactured input[3]; the other includes capital as factor of production. One main results of their study is that food constraints can delay industrialisation. However, Gollin et al. (2007) did not emphasise the role of capital accumulation in such a structural transformation process.

From this previous discussion, the potential for agricultural productivity to generate industrial development, and cause general economic growth is undeniable, particularly in the context of developing countries. It is necessary, however, to note that arguments invoked by these theories assume that close economies. In an open economy, agricultural productivity is neither necessary precondition to industrial take off nor a sufficient condition. The following section reviews the main contribution in that literature.

2.2. Agricultural productivity and industrialisation in an open economy

Authors studying industrialisation process in open economies challenged the traditional view in which agricultural productivity growth bring about industrial development. These authors argued that agricultural productivity would delay industrial development since labour reallocates toward the comparative advantage sector. Matsuyama (1991, 1992) formalised that idea by showing that the demand and supply channels are not operative in a small opened economy that faces perfectly elasticity of demand for goods at world prices. In other words, unlike to close economy, open economy trades with other countries, thus it can export and import goods. That possibility weakens the dependence on agricultural sector.

Matsuyama (1992) investigates the role of agricultural productivity in economic development using two-sector model of endogenous growth in which preferences are non-homothetic and the income elasticity of demand for the agricultural good is less than unitary, and the main engine of growth is learning-by-doing in the manufacturing sector. In the case of close economy, the model predicts a positive relationship between agricultural productivity and industrialisation, while in the case of small open economy, agricultural productivity negatively affects industrialisation. Moreover, Matsuyama (1992) highlights that the early industrialisation of Belgium and New England was possible because of their agricultural import from Holland and South of the United State respectively. Similarly, Matsuyama (2009) argued that if a country is opened to international trade, high productivity growth in a sector does not have to affect negatively employment in that sector.

Duranton (1998) analyses the role of agricultural productivity on industrialisation in an open economy using a Ricardian model. By introducing both international trade and transport cost, he has been able to reconcile traditional and modern approach. His findings suggest that with high transport costs, each country is left in autarchy and the traditional argument is valid. The rationale is that a higher agricultural productivity enlarges the market for the manufacturing goods, such that above a given threshold, industrialisation occurs and the modern technology replace the traditional technology. In contrast, with low transport cost each country can be liken to a small open economy, and due to decreasing return in agricultural sector and increasing return in industrial sector, multiple equilibria arise. In this case, agricultural productivity negatively influences industrialisation.

Nevertheless, Duranton's model suggests that industrialisation may also occur through a change of equilibrium after a perturbation taking the form of a positive (or negative) agricultural shock. As in Matsuyama, his model suggests that the role of agricultural productivity may not be as important as in the industrialisation process as previously though. Rowthorn and Ramana-Ramaswamy (1997) highlighted that in city-state such as Hong-Kong and Singapore, with no large agricultural sector, they did not experience the shift in employment from agriculture to industry that is associated with the industrialisation.

[3] This approach is use to mimic some features of the green revolution in developing countries.

Recently, Bustos, Caprenetti, and Panticelli (2016) have studied the effects of the adoption of new agricultural technologies on structural transformation in Brazil. They build a model describing the relationship between the two sectors in a small open economy where the effect of agricultural depends on the factor-bias of technical change. Their model predicts that a Hicks-neutral increase in agricultural productivity induces a reduction in the size of the industrial sector as labour reallocates toward agriculture. However, in their setting agricultural production comprises two inputs, land and labour that are complement[4]. This specification leads to new prediction, as technical change is labour asymmetry, an increase in agricultural productivity leads to a reallocation of labour toward the industrial sector even in open economies. Bustos, Caprettini and Panticelli (2016) test the predictions of the model by studying the introduction of genetically engineered soybean in Brazil, which has heterogeneous effects on agricultural productivity across areas with different soil and weather characteristics. They use municipalities as their geographical unit of observation, which are assumed to behave as the small open economy described in the model. Findings indicate that technical change in soybean production led to industrial growth as predicted by the model.

Teignier (2015) analysed the role of trade in the structural transformation of United Kingdom and South Korea over the period 1800-1900 and 1960-2007, respectively. He introduced international trade into a neoclassical growth model with two sectors, agriculture and manufacture. A key feature of the model is the low-income elasticity of agricultural goods. Consequently, in the close economy model, as country get richer labour move out from agriculture and into the other sector. International trade accelerates this transition for countries with comparative advantage outside agriculture. Their findings suggest that international trade in agricultural goods can accelerate the structural transformation of countries with low agricultural productivity because it gives the possibility of importing part of their food needs.

2.3. Feedback effects from industrialisation to agricultural productivity

Although large existing literature studies the role of agricultural sector development in industrialisation, by arguing that agricultural productivity strongly impact development of industrial sector, there are many reasons that suggest a possible causality going from industrial development to agricultural productivity. In other words, industrial development matters for agricultural productivity.

Agricultural sector development benefits from industrial growth insofar as agricultural productivity depends heavily on the provision of "modern" input and technology from industrial sector, and consumption goods (Hwa, 1988). Industrial productivity due to improvement in technology can generate spillover effect in agriculture and hence cause growth in agricultural sector (Gemmell et al., 2000). This causality is well observed in real world. In effect, industrialised countries are those having a more productive agricultural sector. In contrast, in countries that fail to industrialise, agricultural sector is less productive and remains dependent on natural conditions.

On the other hand, an increase in industrial sector wage results in a reallocation of labour from agriculture to manufacture, which in turn increases labour productivity and value added per worker in agricultural sector. Wage differential between industrial and agricultural sector is among the main determinant of labour migration toward industrial sector. Higher wage also enlarges the market of agricultural goods, leading farmers to increase their productivity to meet demand.

2.4. Empirical Literature

Few studies have analysed the direct link between agricultural productivity and industrialisation using macroeconomic indicators. Instead, existing empirical literature has emphasized on the agricultural productivity-growth nexus. Our study is related to the latter literature by assuming that growth is generated through resources transfer from low productivity agricultural sector to high productivity industrial sector. Econometrically, the relationship between agricultural development and economic growth or industrial development has been analysed using cross-section, time series, and panel data approaches.

2.4.1. Cross-section analysis

Cross section approach has been widely used in empirical researches to assess the impact of agricultural productivity on industrialisation. For instance, Stern (1996) regresses the average rate of economic growth on the rate of agricultural growth for a sample of developing countries. His results show that there exists a significant and positive relationship for the period 1965-1980 but not for the period 1980-1990. His findings thus suggest that robustness depends on the period of analysis. Echevarria (1997) using a sample of 62 countries over the 1970-1987 show that there is evidence of a positive relationship between average rate of growth and agriculture's share of GDP. However, these studies emphasised on growth rather that industrialisation itself. While in most developed countries the process of economic growth and industrialisation went hand in hand, recent experience of African

[4] Matsuyama (1992) considered only one input, labour.

countries shows that an economy can have an economic growth without industrialisation. Thus, suggesting that economic growth and industrialisation have not to be used interchangeably.

Hwa (1988) provides interesting empirical evidence of the contribution of agriculture to economic growth using cross-section data. After providing an explicit equation relating change in industrial sector to change in agricultural sector, he provides evidence by using two cross-country sample: one consists of 63 countries for the decades of the 1960s and the other 87 countries for the decades of 1970s. By using the ordinary least squared method to estimate each model, his main findings show that agricultural growth, while strongly linked to industrial growth over the development process, contribute to overall growth through its favourable impact on total factor productivity. Moreover, in fostering productivity, the role of agriculture seems to be no less important than that of export performance. This result suggest that agricultural development is a potent element to bring about industrial take off and should be given priority and be properly integrated in development strategy.

However, these studies do not account for the direction of causality and ignore time series dimensions. Cross section approach implies we analyse the long run relationship. Yet the relationship between agricultural productivity and industrialisation may differ according to time horizon. The availability of time series data has opened new opportunities in empirical research as it allows researchers to be able to address a number of issues, namely the causality issues and the short run and long run estimation.

2.4.2. Time series Analysis

Among studies that take into account time series dimensions, Gemmell and al. (2000) can be considered as most relevant starting point. Gummel and al. (2000) investigate the importance of intersectoral linkages for agricultural growth in Malaysia. By adapting the Feder's (1982) growth model of to a time series context, they derive an estimable equation that relates agricultural value added to only manufacturing value-added in the two-sector, or to manufacturing value-added and services value-added in the three-sector model. Through this framework, they provide a justification for the adoption VAR approach to estimate their model, which allow them to circumvent the endogeneity issues and allow for analysis of Granger causality among the model's variables. Their findings show that expansion of manufacturing output causes negative agricultural growth in the short-run, but positive agricultural growth in the long run, "suggesting that the benefit of higher productivity in manufacturing tend to spill over to agriculture". By contrast, expansion of the agricultural sector does not affect the other sectors of the economy, manufacture and service sectors. Thus, their results indicate unidirectional causality, going from manufacture to agricultural sector. This contradicts the conventional argument in agricultural-led growth literature.

Kanwar (2000) takes a similar econometric approach to demonstrate in the case of India. He shows that while the agricultural sector affects the process of income generation in the manufacturing sector, the reveres does not hold. Kanwar (2000) justifies his finding by relating on the standard arguments that agricultural growth relaxes the wage goods, raw material, and foreign exchange constraints and provides a potentially large market for manufactured products.

Other authors studied the role of agricultural sector development in the economic growth in a sample of countries. For example, Gollin et al., (2002) observed in a sample of 62 developing countries over the period 1960 - 1990 that improvements in agricultural productivity would help free up resources for other non-agricultural activities, which would favour economic growth. They provide supporting evidence that growth in agriculture is central to economic growth and development in poor countries. To justify their findings, Gollin et al., (2002) mentioned two stylized facts. First, there was a negative relationship between agricultural productivity and the share of employment in agriculture. Second, there was a positive relationship between the growth of agricultural productivity and the transfer of labour to other non-agricultural sectors.

In the same vein, using the Granger causality test in the panel data for 85 countries,[5] Tiffin & Irz (2006) addressed the question of causality between agricultural value added per worker and Gross Domestic Product (GDP) per capita. Their main contribution is to consider the effect of bootstrapping the Granger causality test and show that it improves the size of the test in short time series in comparison with the use of asymptotical critical values. The main finding is that agricultural value added is the causal variable in developing countries, while the direction of causality in developed countries is unclear. This result is consistent with the popular paradigm that considers that agricultural productivity growth is necessary to economic growth because it releases a surplus of food, labour raw materials, capital, and foreign exchange, while simultaneously generating demand for industrial good.

Awokuse & Xie (2015) examined causal linkages between agriculture and gross domestic product growth in 15 developing and transition economies in Africa, Asia and Latin America with the aid of directed acyclic graphs. Their results suggest that while agriculture could be an engine of economic growth, the impact varies across countries. In some cases, we found strong evidence in support of the agriculture-led growth hypothesis. In

[5] His data comprise 31 African countries

contrast, the results for some other countries indicate that having a vibrant aggregate economy is a prerequisite for agricultural development.

In Africa, most studies investigate agricultural growth and economic growth linkage. In most cases, they find that agriculture contribute significantly to the process of economic growth. Iyoha & Oriakhi (2002) found that agriculture is one of the main sources of economic growth in Nigeria. They also noted that the agriculture share in total labour force was too high and suggested reallocating some of it to other sectors of the economy to accelerate economic growth. Recently, Olajide et al. (2012) showed also that agriculture has a positive impact on Nigerian economic growth from 1970 to 2010. For Odetola & Etumnu (2013) and Oyakhilomen & Zibah (2014) the same positive impact in Nigeria for the periods 1960-2011 and 1970-2011 has been found, respectively.

2.4.3. Panel data

Using panel data of 52 developing countries, Gardner (2003) found no significant evidence that agriculture is the engine of economic growth. Finally, using the Granger causality test and cointegration in panel data for 85 countries, Tiffin & Irz (2006) found evidence that supports the conclusion that agriculture is a source of economic growth in developing countries, but that the direction of causality in developed countries is unclear.

Recently, Diao, McMillan, & Wangwe (2018) Using data from the Groningen Growth and Development Centre's Africa Sector Database, they show that manufacturing employment and its share in total employment is growing in a number of African countries. They explore the extent to which this can be linked to agricultural productivity, which has also been growing in much of Africa over the past two decades. Their findings show that in countries that have successfully industrialised, there is a strong positive correlation between labour productivity growth in agriculture and the manufacturing employment share up until the point at which the manufacturing employment share peaks. According to their results since 1996, there is also a positive correlation between labour productivity in agriculture and the manufacturing employment share in Africa. They explore the mechanisms behind these correlations and find evidence supporting the idea that increases in agricultural productivity have been associated with reductions in the employment share in agriculture and increases in income and the demand for locally produced products.

III.Theoretical Framework

The present chapter examines the role of agriculture in industrial process. Our theoretical framework is based on the model of Matsuyama (1992), which postulates that for the closed economy case a positive link between agricultural productivity and industrialisation, while, for the small open economy case, it predicts a negative link. First, rising productivity in food production makes it possible to feed the growing population in the industrial sector. With more food being produced with less labour, it releases labour for manufacturing employment. Second, high incomes generated in agriculture provide domestic demand for industrial products. Third, it increases the supply of domestic savings required to finance industrialization. In Law of Comparative Advantage, which implies a negative link between agricultural productivity and industrialization, Low productivity in agriculture implies the abundant supply of "cheap labour" which the manufacturing sector can rely on.

key to understanding these two conflicting views can be found in the difference in their assumptions concerning the openness of economies. In an open trading system, where prices are mainly determined by the conditions in the world markets, a rich endowment of arable land (and natural resources) could be a mixed blessing. High productivity and output in the agricultural sector may, without offsetting changes in relative prices, squeeze out the manufacturing sector. Economies which lack arable land and thus have the initial comparative (but not necessarily absolute) advantage in manufacturing, on the other hand, may successfully industrialize by relying heavily on foreign trade through importing agricultural products and raw materials and exporting manufacturing products.

Formerly, let us consider an economy consisting of two sectors: manufacturing and agriculture. Both sectors employ labour. Let Y_t^M denotes the manufacturing output at time t, Y_{it}^A is the agricultural output at time t, n_t is the fraction of labour employed in manufacturing as of time t. Technologies in the two sectors are given by

$$Y_{it}^M = M_t F(n_t), \quad F(0); \qquad F' > 0;\ F' < 0 \qquad (1)$$

$$Y_{it}^A = AG(1 - n_t), \qquad G(0); \qquad G' > 0;\ G' < 0 \qquad (2)$$

A and M_t represent the agricultural and manufacturing productivities. $F(.)$ et $G(.)$ represent the production function of manufacturing and agriculture. The standard assumption in our specification is that labour is the main input in the economy and manufacturing sector allows for doing work through learning by doing. Both sectors operate under diminishing returns. Agricultural productivity endowment, and climate, among other things, is constant over time and treated as an exogenous parameter. On the other hand, productivity in the manufacturing sector, M, which represents knowledge capital as of time t, is predetermined, but endogenous. Knowledge accumulates as a by-product of manufacturing experience, as follows

$$\dot{M}_t = \delta Y_t^M,\ \delta > 0 \qquad (3)$$

If the economy is open agriculture and industrial sector are negatively related with each other.
We replace the open-close dichotomy with economies which differ along a continuum of openness. The specification is such that the effect of A on n is allowed to vary in accordance with a smooth transformation function, g :

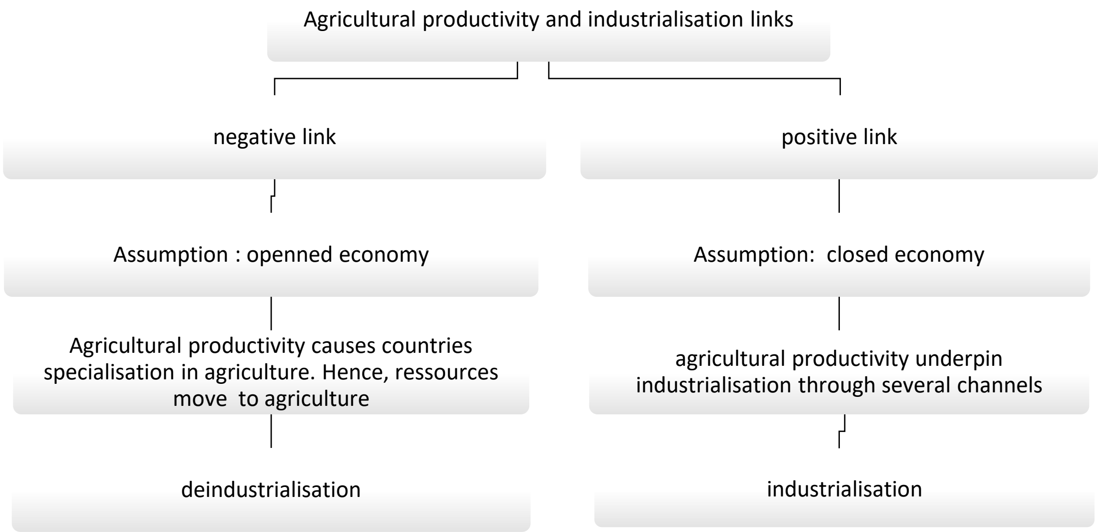
$$n = (\beta + \delta g)A + Y_{\eta} + u \quad (4)$$

Where g is the function of economic openness or trade openness. Different degree of trade openness will result in different coefficient like $\beta + \delta g$. We use a logistic function to g specification:

$$g = \frac{1}{1+e^{-\gamma(openness-c)}} \quad (5)$$

Where γ and c are the factors for estimation and the value of g lies between 0 and 1. The effect of agricultural productivity on industrialisation equals to $\beta + \delta.\frac{1}{1+e^{-\gamma(openness-c)}}$ and the coefficient of closed and open economies are β and $\beta + \delta$ (where β and $\beta + \delta$ depend on $\gamma < 0$ and $\gamma > 0$). So, with increase openness, the effect of agricultural productivity on industrialisation decline.
A diagrammatic representation of link between agricultural productivity and industrialisation is given in figure 1. Thus, according to Matsuyama (1992)'s model agricultural productivity is harmful to industrialisation in globalised world. However, any shocks on the economy can bring about industrialisation.

Figure 1: Link between agricultural productivity and industrialisation



Author's construction, based on theoretical framework

IV.Data and Empirical Methodology

4.1. Model specification of Model

This section discusses the model specification to examine the impact of agricultural productivity on industrialisation. The model is derived from Hwa (1988) who analysed the relationship between agriculture and industry using non-linear model of the Chenery and Syrquin (1975), which relate the rate of industrial growth to per capita income and the rate of agricultural growth. Our model is modified in two manners in order to account for agricultural productivity and other variables that might affect industrialisation. Our model can be derived as follows:

$$\ln(mva) = f(\ln(agrpw), ln(gdppc)) + u, \quad (6)$$

Where u is a randomly distributed error term. First, we assume that the rate of agriculture growth and industry are both non-linear function of per capita income variable:

$$mva = \alpha_{mva}\ln(gdppc) + \varepsilon_{mva} \quad (7)$$

And

$$agr = \alpha_{agr}\ln(gdppc) + \varepsilon_{agr} \quad (8)$$

Where ε_{mva} and ε_{agr} are random error.
Equation (7) and (8) are simplified reduced form models for determination of industrial and agricultural growth. The per capita income variables are used to summary measure of the stage of economic development, in addition to being measures of final demand. Chenery and Taylor (1968) used the same models to study patterns economic development. From these equations, it is possible to test relationship between industrial growth and agricultural growth, that is, whether countries with higher industrial growth are also those with higher agricultural growth. This test can be made by regressing the residual in (7) and (8):

$$\varepsilon_{mva} = \gamma\varepsilon_{agr} + u \quad (9)$$

Where u is a randomly distributed error term. Substituting (7) and (8) and rearranging the terms yield

$$\ln(mva) = \gamma agr + (\alpha_{mva} - \gamma\alpha_{agr})\ln(gdppc) + u \quad (10)$$

This equation represents the explicit form of equation (6). It also implies that the disparity between industrial and agricultural growth is a linear function of per capita income.

We modify the last equation in following manner. First, we use agricultural productivity rather than agricultural growth insofar as a country can experience agricultural growth due to extensively use of inputs. Secondly, we include four control variables to avoid endogeneity problems stemming from omitted variables. Following Kaya (2010) and author (Gui-Diby and Renard, 2015) we include the rate of growth of the capital stock, labour force, and trade openness as controls variables.

Following previous studies, we approximate the rate of the capital stock by the share of investment in GDP. This is necessary due to problems associated with attempt to measure capital stock especially in the context of African countries. In addition, we also replace the rate of change in labour input by the growth rate of population. On the other hand, we account for country's quality of institutions by including civil liberties index from Freedom House. These yields following industrial development equation:

$$\ln(mva) = \alpha + \beta_1\ln(agrpw) + \beta_2\ln(gdppc) + \beta_3 ln(inv) + \beta_4\ln(pop) + \beta_5\ln(trade) + \beta_6 cl + u \quad (11)$$

We are interested in test whether the elasticity industrialisation with respect to agricultural labour productivity, β_1, is negative and statistically significant. The expected signs of the coefficients β_3 , β_4 , β_5 and β_6 is negative. However, in African context, some studies findings showed that trade openness, investment, population have negative effect as well.

4.2. Data

We select the countries by data availability. The data contains an almost balanced panel except some years, an average of the before and after values are used to balance the panel. Our Main Source of data is World Banks World Development Indicator (2024) and Freedom House (2024). The analysis covers 17 countries in Africa over the period 1991-2022. For these countries, three are in North Africa (Egypt, Morocco and Tunisia) and fourteen are in sub-Saharan.

As it is standard in the literature, the dependent variable is the ratio of industry value added to GDP. In order to reduce misspecification due to omitted variables, we include a number of variables as control variables. Based on our theoretical literature and industrialisation empirical literature we use the most selected variable in the literature, namely investment, trade openness, population, gross domestic product per capita, civil liberties (see Haw, 1998; Kaya, 2010). All variables except for civil liberties will be expressed in logarithm form. The detailed description of variables of each country is given in Table 1.

Table 1 : Description of variables used in this chapter

Variable	Proxy	Definition	Source
Mva	Industrialisation	Manufacturing value added to GDP	World Development Indicator, 2024
agri_pw	Agricultural productivity	Agricultural value added per worker	World Development Indicator, 2024
Trade	Trade openness	Export plus import to GDP	World Development Indicator, 2024
Gdppc	Economic development and size of the market	Gross domestic product per capita,	World Development Indicator, 2024
Pop	Size of market	Population, growth	World Development Indicator, 2024
Inv	The rate of stock of capital	Gross fixed capital formation to GDP	World Development Indicator, 2024
Cl	Quality of institutions	Civil liberties	Freedom House

Source: author's construction

4.3. Descriptive statistic and Correlation matrix for selected variables

The descriptive statistics are shown for dependent and independent variable. Dependent variable is manufacturing value added to GDP whereas, independent variables are agricultural labour productivity, investment, gross domestic product per capita and it square, trade openness and population growth. Then, the correlation coefficient is based on 17 African countries with 519 observations for the period 1991 to 2022.

Table 2: Summary statistics

Variable	mean	Sd	xtn	obs	xttbar
ind_gdp	25.98	11.23	17	540	31.76
agri_pw	2546.67	2595.51	17	544	32.00
gdppc	2283.20	2096.25	17	544	32.00
trade	66.59	31.06	17	544	32.00
pop	1.89e+07	2.19e+07	17	544	32.00
inv	20.91	8.45	17	544	32.00
Cl	4.04	1.37	17	543	31.94

Source: Author's computation

The within and between variations are also computed as summary provision of panel data. The analysis incorporates three important variations: the overall, the between, and the within variations**.** Table 3 summarizes our data in terms of the means and standard deviations. The standard deviation is broken down into the two dimensions of the panel, i.e., between countries ("Between") and over time, within countries ("Within"). As the table shows, the within component of our dependent variable (the logarithm of industry value added to GDP (L_ind_gdp) is low (lower than the mean, and lower the between component). For all explanatory variables, the between standard deviation is larger than within counterpart. This means that the explanatory variables exhibit more variation between countries than they are over time (within countries).

Table 32 : Summary statistics of variables in log

Variable	Mean	sd	sd between	Xtn	min	max	obs	xttbar	sd within
L_mva_gdp	1.03	0.26	0.2	17	0.2	1.5	542	31.88	0.1
L_ind_gdp	1.38	0.19	0.2	17	0.6	1.9	540	31.76	0.1
L_agri_pw	3.22	0.40	0.4	17	2.4	4.2	544	32.00	0.1
L_gdppc	3.18	0.41	0.4	17	2.3	4.0	544	32.00	0.1
L_trade	1.78	0.19	0.2	17	1.4	2.2	544	32.00	0.1
L_pop	6.97	0.56	0.6	17	5.9	8.0	544	32.00	0.1
L_inv	1.28	0.20	0.1	17	-0.5	1.9	543	31.94	0.2
Cl	4.04	1.37	1.2	17	1.0	7.0	543	31.94	0.7

Source: Author's computation

The results of the correlations are reported in table 4. According to the partial correlation results, the explanatory variables, population (L_pop) has significant negative relationship with industrialisation (L_ind_gdp), whereas agricultural labour productivity (L_agri_pw), economic development (L_gdppc), investment (L_inv), trade openness (trade), institutions (cl) have positive significant relationship with the industrialisation.

Table 4: Coefficient of Correlation

	L_ind_gdp	L_agri_pw	L_gdppc	L_trade	L_pop	L_inv	Cl
L_ind_gdp	1						
L_agri_pw	0.240***	1					
L_gdppc	0.525***	0.784***	1				
L_trade	0.483***	0.572***	0.634***	1			
L_pop	-0.096**	-0.187***	-0.117***	-0.568***	1		
L_inv	0.244***	0.140***	0.283***	0.288***	-0.013	1	
Cl	0.081*	-0.198***	-0.367***	-0.213***	0.173***	-0.179***	1

Source: Author's estimation

The results show also that the pair of agricultural productivity and economic development variables has the highest coefficient (0.784). Besides, among other explanatory variables coefficients of correlation are moderate.

4.4. Panel unit root tests

As it is now a common practice for empirical research that involve time series dimensions, before estimating our model we check for order of integration of variables used in our model. Panel unit root tests are separated into "first generation panel unit root test" including LLC test (Levin, Lin, & Chu, 2002), IPS test (Im, Pesaran, & Shin, 2003), MW test (Maddala and Wu, 1999) and Choi test (Choi, 2001) and the "second generation panel unit roots tests" containing MP test (Moon and Perron, 2004), Pesaran test (Pesaran, 2007) and (Choi, 2001) test. First generation tests do not allow for cross sectional dependence between units; however, second generation tests take into account the cross-sectional dependency. Therefore, we test for cross section dependence before choosing which panel unit root tests are more appropriate.

4.5. Cross Section Dependence

This study initially employs cross section dependence (CD) test developed by Juodis and Reese (2021). The CDw test proposed by Juodis and Reese (2021) is designed to assess cross-sectional dependence in panel data, particularly within unbalanced panels where traditional tests may lack power or produce biased results. Cross-sectional dependence, which refers to correlation between units across different time periods, is common in economic data and may arise from factors such as shared economic policies, trade relationships, or common shocks that simultaneously affect multiple units. Detecting this dependence is crucial because its presence can invalidate standard inference methods, making corrections necessary to obtain unbiased estimates.

Traditional tests, like the Pesaran (2004) CD test, are often calibrated for balanced panels and may not perform well with unbalanced data. The CDw test adjusts for this by providing a robust means of detecting weak forms of cross-sectional dependence that might otherwise be overlooked.

The CDw test assesses the null hypothesis of weak cross-sectional dependence versus the alternative of significant dependence. The test statistic is derived from the sum of cross-sectional correlations between residuals of each pair of units in the panel. Under the null hypothesis, these correlations are assumed to average out to zero as the panel dimensions grow, indicating no pervasive correlation across units. A high p-value indicates a failure to reject the null hypothesis, suggesting no significant cross-sectional dependence; in contrast, a low p-value would signal a need to account for dependence across units, potentially by adjusting the model with corrections such as cross-sectional averages or factor structures.

4.6. Estimation techniques

We specified our model to estimate the impact of agricultural productivity on industry growth as follows:

$$L\_mva_{it} = \alpha_i + \beta_1 * L\_agrpw_{it} + \beta_2 * L\_gdppc_{it} + \beta_4 * L\_inv_{it} + \beta_5 * L\_trade_{it} + \beta_6 * L\_pop_{it} + \beta_6 * cl_{it} + \varepsilon_{it} \quad (12)$$

Where L_*agrpw* stands for the logarithm of agriculture value added per worker, i represents the i_{th} country and *t* represents year.

The Pooled Mean Group (PMG) approach is used to estimate dynamic heterogeneous panels by considering long-run equilibrium relationship, contrary to other techniques, such as the dynamic panel GMM method, that purge any potential long-run linkage among variables. The PMG estimation approach allows identical long-run coefficients without assuming homogeneous short-run parameters. Based on this assumption, the PMG estimation approach differs from techniques, such as the Mean Group (MG) developed by (Pesaran and Smith, 1995), that estimate a regression for each group and then calculate the coefficient means (Evans, 1997; Wagner et al., 2001). The MG long-run estimators are consistent, but they are inefficient if coefficient homogeneity holds. Under these conditions, the PMG estimation approach is useful since it provides consistent and efficient long-run estimators when parameter homogeneity holds. In addition, the PMG approach is preferable to the MG method because it provides estimates that are less sensitive to outlier estimates.

Our equation (1) can be written as unrestricted specification for the system ARDL equations for $t = 1,2,\dots,T$ and $i = 1,2,\dots,N$

$$y_{it} = \sum_{k=1}^{p} \delta_{ik} y_{i,t-k} + \sum_{k=1}^{q} \lambda_{il} x_{i,t-k} + \eta_i + \varepsilon_{it} \quad (13)$$

Where y, denotes manufacturing value added to GDP ($mvagdp$), x_{it-j} represents the vector explanatory variable, including agricultural labour productivity, for group i , and η_i is the fixed effects. Reparametrizing equation (2) as VECM system we obtain the following equation

$$\Delta y_{it} = \theta_i\left(y_{i,t-1} - \beta_i' x_{i,t-1}\right) + \sum_{k=1}^{p-1} \delta_{ij}\, \Delta y_{i,t-j} + \sum_{k=1}^{q-1} \lambda_{il}' \Delta x_{i,t-j} + \eta_i + \varepsilon_{it} \quad (14)$$

Where θ_i represent the error correction parameters and β_i are the long-run parameters. Applying the pooled mean group restriction to equation (3), that is $\beta_i = \beta$. In other words, β are common across the cross-section.

$$\Delta y_{it} = \theta_i\left(y_{i,t-1} - \beta' x_{i,t-1}\right) + \sum_{k=1}^{p-1} \delta_{ij}\, \Delta y_{i,t-j} + \sum_{k=1}^{q-1} \lambda_{il}' \Delta x_{i,t-j} + \eta_i + \varepsilon_{it} \quad (15)$$

Following Pesaran et al. (1999), we apply the maximum-likelihood method to estimate equation (4) by initially assuming that the error terms are normally distributed.

We address endogeneity concerns by augmenting the PMG estimator with lags of independent variables and dependent variables to minimize the resultant bias and ensure that the regression residuals are serially uncorrelated. We conducted the test of Maddala and Wu (MW, 1999). These tests are a generalization of the Augmented Dickey–Fuller test (ADF).

V. Empirical results

5.1. Cross Section Dependence Tests Results

We beginning our analysis by testing the presence of cross section dependence in our sample. The results of the cross-sectional dependence test indicate a CDw statistic of -0.01 with a p-value of 0.991. This test, proposed by Juodis and Reese (2021), is particularly suitable for unbalanced panels. In this case, the high p-value of 0.991 leads us to not reject the null hypothesis of weak cross-sectional dependence. This means that, according to the CDw test criterion, there is no significant dependence between the cross-sectional units, suggesting that adding specific corrections for dependence between units is not necessary for this model.

Table 4: Cross sectional dependence

Cross sectional dependence	CDw	p-value
Res	-0.01	0.991

Source: Author

5.2. Panel Unit Root Tests Results

Before we embark on the estimation of the long-run equilibrium using PMG estimation, we must first try to establish the stationary of our data series. We adopt the panel unit roots approach of Maddala & Wu (1999) to establish the stationary of the variables. The unit root tests are conducted at both the levels and first-difference. The results are given in Table 21. The results indicates that most variables are non-stationary at level, with p-values above the conventional significance threshold (5%). This includes variables such as industrial value added as a percentage of GDP (L_ind_gdp), agricultural value added per worker (L_agri_pw), per capita GDP (L_gdppc), trade openness (L_trade), and population (L_pop). However, two variables stand out as they are stationary at level with p-values of 0.000. These are gross fixed capital formation (L_inv) and civil liberties (cl). These results suggest that the use of PMG may be appropriate, as this estimator remain consistent irrespective of order of integration.

Table 5: Panel data Unit root test for the variables that will be used in the regression

Variable	Level	First difference
L_ind_gdp	34.5559 (0.4412)	251.4616 (0.000)
L_agri_pw	14.7233 (0.9984)	377.9383 (0.000)
L_gdppc	19.3143 (0.9797)	223.3446 (0.000)
L_trade	45.5730 (0.0887)	283.0418 (0.000)
L_pop	24.6140 (0.8812)	212.0642 (0.000)
L_inv	82.2636 (0.000)	384.7489 (0.000)
Cl	93.9972 (0.000)	376.9742 (0.000)

Source: Author's computation

5.3. Pooled Mean Group Results

This section is devoted to the empirical analysis of the agricultural-led industrialisation hypothesis. Specifically, we examine the following questions: Does agricultural productivity affect industrialisation in Africa? The results for PMG estimation are given in Table 22.

The results from data analysis reveal that agricultural productivity negatively significantly affects industrialisation in Africa, at least for countries in our sample, over the time period considered. Our estimation showed 1 % increase in agricultural labour productivity leads to -0.311 % decrease in industry value added to GDP. The negative effect of agricultural productivity on industrial output in Africa (-0.311) aligns with the "structural transformation trap" described by Matsuyama (1992). Matsuyama posits that increases in agricultural productivity can reinforce an economy's dependency on agriculture by retaining labour within the sector, thereby reducing industrial expansion. This "anti-industrialisation" effect has significant implications for African economies, where a large share of employment is in agriculture, potentially reinforcing low-productivity traps that prevent economic diversification. Consistent with this view, Dercon and Gollin (2014) argue that without targeted policies that redirect labour towards industry, agricultural productivity gains may fail to support structural transformation. This result supports Sachs and Warner's (2001) notion of the "resource curse," which suggests that economies highly reliant on primary sectors risk slow diversification, a phenomenon common in resource-rich African countries.

The positive relationship between per capita GDP (0.209) and industrialisation is consistent with theories of urbanisation and agglomeration economics put forward by Duranton and Puga (2004). Their work highlights that urbanisation centralises economic activity and enhances productivity by concentrating resources and facilitating resource sharing among industries. This effect is particularly relevant to Africa, where growing urban centres are beginning to drive demand for manufactured products, laying the foundation for a domestic market for industrial goods. Duranton (2015) emphasises that effective urbanisation policies are necessary to harness this potential, advocating for investments in infrastructure and affordable housing to support rural-to-urban migration. These insights resonate with Lewis's (1954) theory on the role of income growth in stimulating demand for manufactured goods, which can, in turn, catalyse industrial development. Recent empirical work by McMillan et al. (2014) on structural transformation in Africa also supports this view, highlighting the importance of urban-led demand in driving industrialisation.

The positive and significant impact of trade openness (0.437) on industrialisation is supported by the findings of Kaya (2010), who shows that trade liberalisation enhances competitiveness in developing economies by providing access to larger markets and foreign investment. The African Continental Free Trade Area (AfCFTA) exemplifies the benefits of regional trade integration in fostering industrialisation by expanding market access and attracting foreign direct investment. Rodrik (2008) further underscores that exposure to international markets can enable African countries to shift away from agriculture and primary goods toward manufactured exports. Balassa (1980) and Dollar and Kraay (2004) have similarly demonstrated that trade openness facilitates technology transfer, supporting industrial growth in emerging economies. The significance of trade as a catalyst for African industrialisation is reinforced by Afesorgbor's (2019) findings on the AfCFTA, which highlight the benefits of regional integration in enhancing manufacturing competitiveness.

The finding that reduced civil liberties correlate with industrialisation, as suggested by a positive relationship between civil liberty scores and industrial output, is consistent with the literature on state-led development in emerging economies. Duranton and Turner (2018) have observed that governments with centralised authority may channel resources into large-scale industrial projects in countries with constrained civil freedoms. This dynamic reflects the experiences of East Asian economies during the 20th century, where centralised governments implemented industrial policies despite limited democratic freedoms (Wade, 1990). We found similar trends in African countries with strong centralised control, where governments have prioritised industrialisation under restrictive political regimes. These insights align with Evans' (1995) argument that state capacity can play a pivotal role in directing resources toward industrialisation under non-democratic governance, though this often involves trade-offs with civil liberties.

Investment is usually perceived as a critical variable in the development process. Using aggregate data, we fail to account for investments across sectors, which will be valuable to assess the volume of investment consecrate to industrial sector. It is well known that investment in African is far to be efficient. Our result show that investment does not affect industrialisation in our sample. On the other hand, the error correction coefficient is negative and significant, implying that there is cointegration between industrialisation and agricultural productivity.

Table 63 : Pooled mean group estimation

Long run cointegration vectors Normalised variable: log of industry (% GDP)	**PMG estimation**	**MG estimation**	**DFE estimation**
Variables			
L_agri_pw	-0.311*** (0.000)	-0.336 (0.148)	-0.402** (0.013)
L_gdppc	0.209* (0.085)	1.361** (0.039)	0.202 (0.388)
L_trade	0.437*** (0.000)	0.480*** (0.000)	0.265 (0.125)
L_pop	0.109 (0.177)	0.035 (0.934)	0.217 (0.294)
L_inv	-0.085* (0.051)	-0.183 (0.109)	-0.012 (0.914)
Cl	0.030*** (0.000)	0.210 (0.456)	0.031 (0.156)
Short run dynamics **Dependent variable:** log of industry (% GDP)			
Error correction	-0.244*** (0.000)	-0.533*** (0.000)	-0.150*** (0.000)
D.L_agri_pw	-0.009 (0.870)	0.523 (0.382)	-0.078 (0.119)
D.L_gdppc	0.264 (0.335)	0.030 (0.897)	0.566*** (0.000)
D.L_trade	0.085** (0.039)	-0.004 (0.939)	0.301*** (0.000)
D.L_pop	1.935 (0.326)	4.986 (0.160)	0.180 (0.570)
D.L_inv	0.014 (0.551)	0.049 (0.126)	-0.123*** (0.000)

D.L_cl	-0.004 (0.658)	0.001 (0.958)	0.002 (0.705)
Constant	0.013 (0.517)	0.039 (0.967)	-0.015 (0.930)
Observation	519		
Hausman test-statistic H0: Difference in coefficient not systematic	4.65 (0.590)		2.54 (0.864)
p-values in parentheses * p<0.05, ** p<0.01, *** p<0.001			

Source: author's estimation

VI. Conclusion

In this chapter, agricultural labour productivity, economic development, globalisation, investment and population is examined. Especially, the role of agricultural labour productivity is tested with special reference to the African countries. We found that there is a negative and significant effect of labour productivity on industrialisation after controlling for other determinants of industrialisation (trade openness, total investment, population and gross domestic product per capita and civil liberties). The results show also that trade openness and gross domestic product have positive effects on industrialisation, at least, for countries under study. The results also suggest that investment is detrimental for industrialisation, and that imply government should pay attention orientation on capital investment across sectors. On the other hand, while countries are becoming increasingly large, in terms of population, our analysis shows that population growth has not significant effect on industrialisation.

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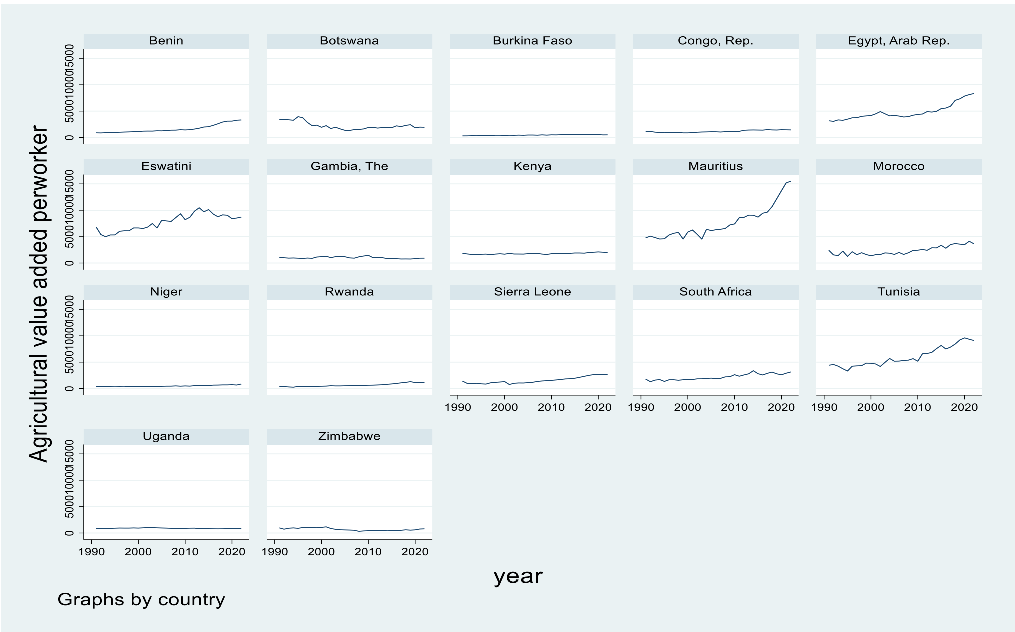
Appendix

Table A.1: List of countries

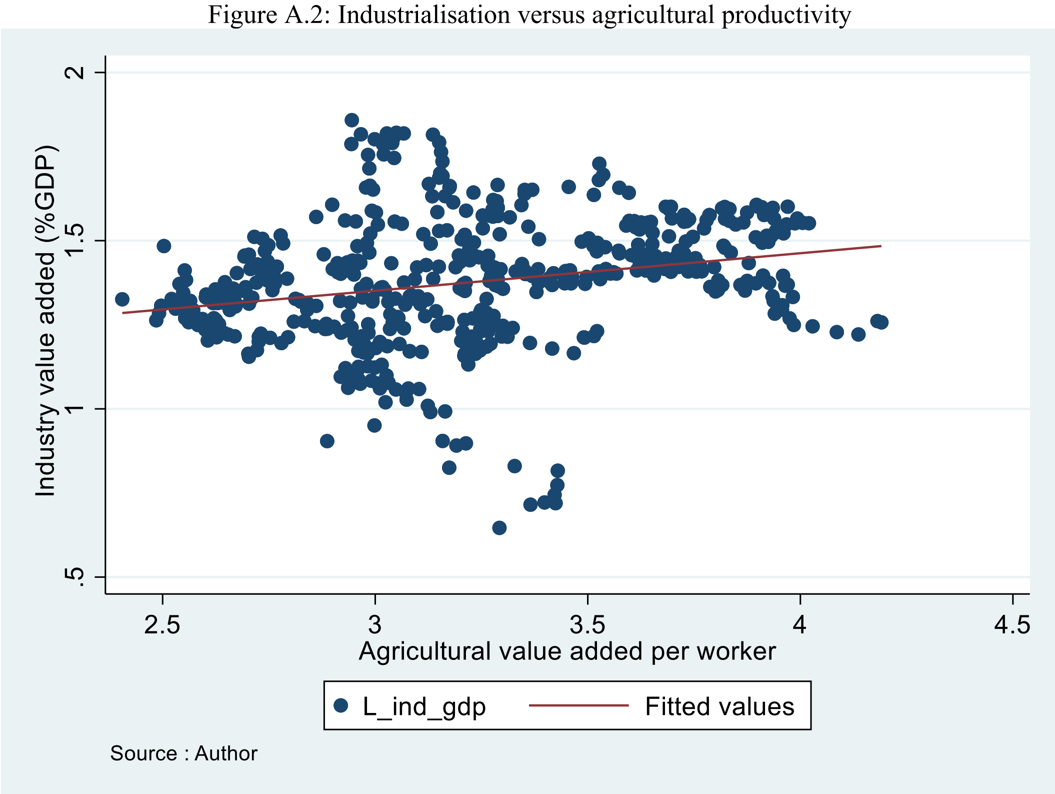
Benin; Botswana; Burkina Faso; Congo, Rep.; Egypt, Arab Rep.; Eswatini; Gambia, The Kenya; Mauritius; Morocco; Niger; Rwanda; Sierra Leone; South Africa; Tunisia; Uganda; Zimbabwe

Figure A.1: Agricultural productivity, 1991-2022



Source: Author

Figure A.2: Industrialisation versus agricultural productivity



Source : Author

Figure A.3: Industrialisation versus agricultural productivity

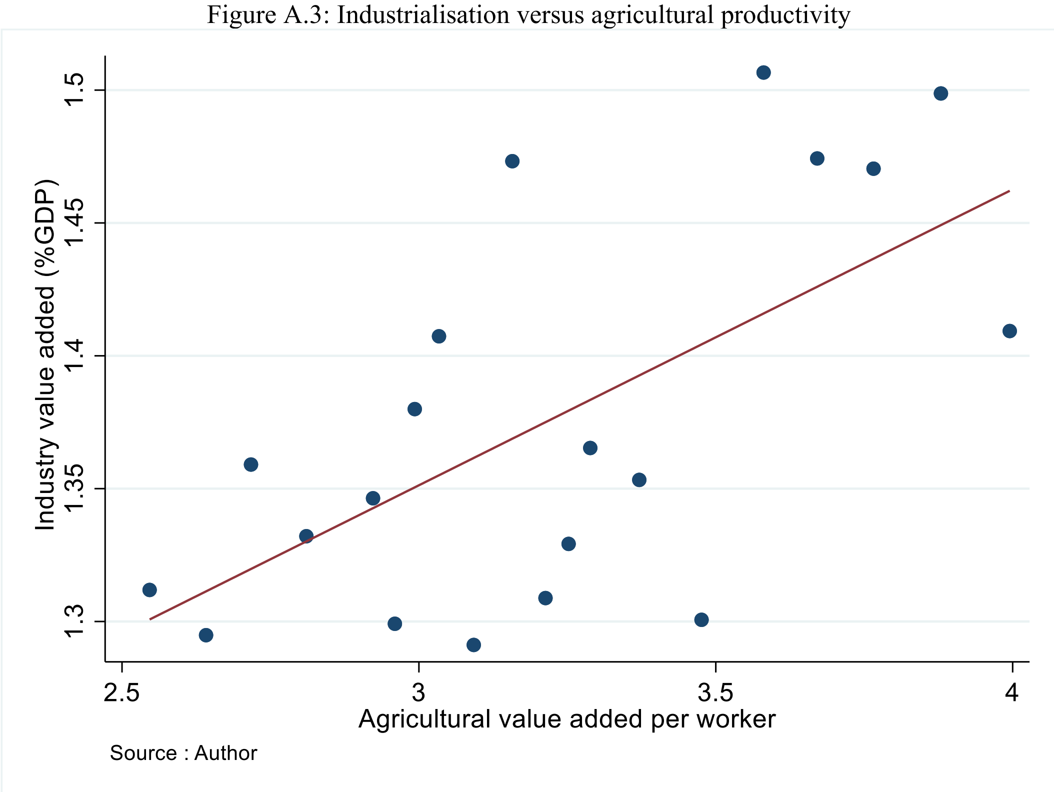
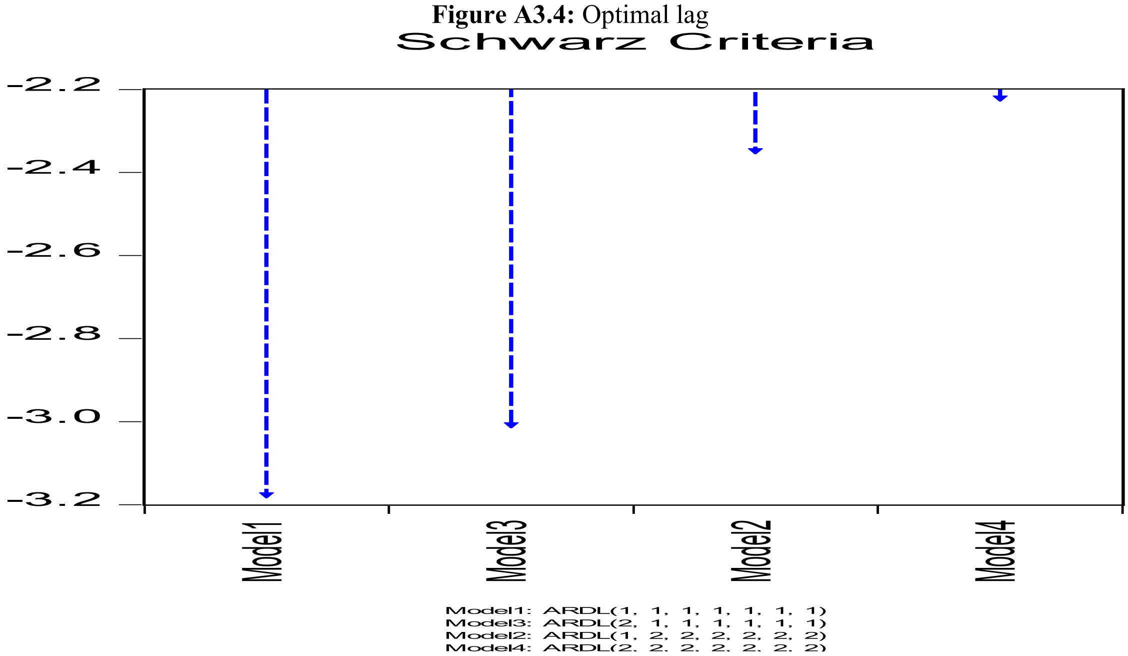


Figure A3.4: Optimal lag



So