The Impact of Extractive Resources on Agriculture Modernisation and Structural Transformation in Sub-Saharan Africa

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- PRELIMINARY AND INCOMPLETE -

Abstract

Agricultural productivity is a key element for development and structural transformation, and it remains dramatically low in most developing countries. This paper assesses the interaction between extractive resources exploitation and the performance of the agricultural sector in Sub-Saharan Africa. The impact of natural resources on agricultural productivity is shown to be negative in the region, in contrast to other developing regions. Further estimates suggest that this is due to a dutch disease effect where resources exploitation is associated with a weak manufacturing sector, whereas this one has the potential to increase the use of fertilisers. Therefore these results suggest that extractive rents dampen indirectly the adoption of modern inputs and thus agricultural productivity.

1 Introduction

In 2016, the level of output per worker in the Sub-Saharan agricultural sector was 25 times lower than that of Europe and 42% of people were living with less than $1,9 USD in 2013 (World Bank, 2016). Raising agricultural productivity is a critical challenge for the continent in order to overcome subsistence needs and allows poverty alleviation (e.g., Diao et al., 2007). This is also important in order to release workers from the agricultural sector so they can reallocate into more productive sectors, and thus raise aggregate productivity and development.

Natural resources extraction plays a crucial and growing role in Sub-Saharan economies. In 1991, the average extractive rents share (% of GDP) was 4.33%, and by 2011 it had almost tripled to reach 11.2%. Most greenfield foreign direct investment (FDI) in Sub-Saharan Afrique (SSA) went to resource-related activities during the last two decades (OECD et al., 2013). The continent's comparative advantage in natural resources seems yet not to meet its economic growth and development potential since it is the only continent facing increasing poverty rates. In the debate of assessing whether resources benefit or not Africa's development and growth, we would rather talk of a 'resource curse'[1], especially compared to the experience of other developing regions. In SSA, given the weak manufacturing sector, we would precisely speak of a dutch disease: the boom of a resource dampens the development of the manufacturing sector (Corden and Neary, 1982).

Yet the manufacturing sector has the highest productivity rate, drives growth and structural transformation in traditional development theories (Herrendorf et al., 2014). It also contributes to modernise agriculture by reducing the intermediate inputs price (for example fertilisers) and thus increases their use (Yang and Zhu, 2013). In Africa most agricultural activities are operated by small-holders, power force used is still human hand force and intermediate inputs use remains low, whereas the latter are important for raising agricultural productivity (McArthur and McCord, 2017).

If the level of industrialisation (manufacturing) of a country is important for agriculture modernisation but that extractive resources dampen its development, could the exploitation of resources be a possible explanation for low agricultural productivity in Africa? Or on the contrary are extractive resources rents a way to increase agricultural productivity through resources windfall used for investments in agriculture?

As the analytical framework, we provide a simple two-sector growth model to guide our empirical study. In this model based on Yang and Zhu (2013), we show that the increase in agricultural productivity can be either driven by the rise of the non-agricultural sector (the manufacturing sector) or by the presence of resources rents. In both cases, the price of modern inputs (fertilisers) declines. Below a certain threshold, farmers adopt modern inputs and agricultural productivity increases, leading to structural transformation.

[1] even though countries such as Bostwana present a resources-led success story.

We then use panel regressions to study the empirical links between extractive resources, agricultural productivity per worker, manufacturing value added and fertilisers using data from the World Bank and FAO from 1991 to 2016. We control for several variables such as population density, trade openness, foreign direct investment (FDI) or terms of trade. First, we show that extractive rents share has a different impact on agricultural productivity depending on the continent considered. We find that extractive rents share is negatively associated with agricultural productivity in SSA, while positively in Latin America and Caribbean (LAC) and Asia. This suggests, as predicted by the model, that natural resources can have either a negative or a positive impact on the agricultural sector and this stresses the need to understand the underlying mechanisms, especially in SSA which is particularly resource-dependent. In this paper, we investigate this region particularity and focus on the role of modern inputs adoption such as fertilisers (agricultural modernisation).

Second, drawing attention on SSA, we show evidence for a dutch disease phenomenon. We estimate the link between extractive rents share and the manufacturing value added (% of GDP), controlling for several variables and we find that an increase of 1% resource share is associated with a decline of 0.056% share of manufacturing value added. Third, our estimates support the fact that the manufacturing sector is associated with an increased use of fertilisers. These results combined suggest that extractive resources can play an important role for agricultural productivity decline because it weakens the manufacturing sector and do not allow for the adoption of modern inputs.

This paper contributes to several strands of literature, starting with the role of agriculture in understanding cross-country income difference (Gollin et al., 2014 ; Lagakos et al., 2013 ; Adamopoulos et Restuccia, 2014 among others). It also contributes to the resource curse literature and more particularly on a subsection of this literature focusing on the dutch disease (e.g. Corden and Neary, 1982; Torvik, 2009; Van der Ploeg, 2011). While in the latter most work focus on the impact of natural resources on the manufacturing sector, our paper additionally investigates the impact on the agricultural sector. Most closely is the work of Yang and Zhu (2013) for the theoretical part and for the empirical part McArthur and McCord (2017), who analyse the effect of fertilisers on cereal yields and its structural transformation implications. They find that fertilisers, modern seeds and water play an important role in boosting yields and their following results suggest that agricultural productivity is an important driver of structural change. Instead of looking at the impact of fertilisers on cereal yield we study the impact of natural resources on agricultural productivity, which can impact the use of fertilisers ahead.

Natural resources' impact on agriculture has been too poorly documented (Dercon and Gollin, 2014), our paper contributes to fill the gap. The contributions of our paper are to (i) highlight SSA's specificity regarding the negative link between natural resources and agriculture and (ii) investigating this particularity by bringing insights on how the dutch disease phenomenon can impact agricultural productivity, through low adoption of modern inputs.

The paper is organised as follow. Section 2 presents the literature. Section 3 presents the analytical framework. Section 4 describes data and observations. Section 5 presents the results. Section 6 concludes.

2 Literature review

A recent literature focuses on the role of agriculture in development strategies[2]. The agricultural sector is larger at the early stage of development and thus it has a potentially important economic role to play in economies' take-off. The underlying mechanism supporting the importance of this sector for development can be found in Schultz (1953) who characterises the 'food problem': labor is trapped in agriculture until they produce more food than their subsistence level. Further research on the subject elaborate on the same idea. Johnston and Mellor (1961) argue that economic policy should focus on agriculture as a starting point of growth. Timmer (1988) recognises agricultural transformation as a key starting point for economic development, where agricultural transformation refers to the shift from a subsistence-based agricultural economy based on small farms to a commercial agriculture relying on the expansion of the agro-business sector.

Despite the importance of agriculture emphasised in development theories, agriculture in Sub-Saharan Africa was neglected or did not benefit from import substitution strategies during the 60s-70s or during the structural adjustment programs of the 80s-90s. Most of resource-rich African countries also focused on their cash crops exploitation rather than developing agriculture for the domestic market. With the adoption of the UN Millenium Development Goals in 2000 and the world food crisis in 2007, there was a renewal interest in the role of agriculture for development. Recent empirical research investigates the relative impact and efficiency of agriculture development rather than other sectors for reducing poverty. Results show that agriculture is on average more poverty reducing, especially for the poorest, so at the earlier stage of development (Diao et al., 2007; Haggblade et al., 2007,

[2]we focus here on the macroeconomic literature. For a detailed literature review of agriculture in development strategies, see Dercon and Gollin (2014).

Ligon and Sadoulet, 2018; Byerlee et al., 2009). For example, Byerlee et al. (2009) in their sample of countries find that those with the highest rates of agricultural productivity growth have the highest rate of poverty reduction.

Yet there is heterogeneity for the relative impact of agricultural development on poverty when considering geography or natural resources for example. Dorosh and Thurlow (2018) focus on sub-sectors in the economy to assess their role on poverty reduction: when considering the same growth in agriculture and in mining, the latter remain limited while agriculture is significantly poverty reducing.[3] Christiaesen et al. (2011) show that in resources-rich countries, growth from the extractive industry dampens its poverty reduction effect. As the authors conclude, the focus on agriculture for development strategies is thus particularly important for resource-rich countries and for countries at the early stage of their development. This is the case for most Sub-Saharan countries, suggesting the importance of agriculture for their development and the decline of poverty on the continent.

Directly linked to this field of research, this paper also contributes to the literature of structural transformation which studies the reallocation of resources across sectors along the growth income path. The move of resources from the traditional and subsistence agriculture toward productive manufacturing and services sector has historically been the pattern of development of today's rich countries (Syrquin 1988, Herrendorf et al. 2014) and the starting point of this trend consist in improving agricultural productivity (Gollin et al., 2002). Investigating structural transformation in SSA gives insights on the sustainable growth and poverty alleviation it can achieve.

A specific part of this literature focusing on agriculture productivity investigates why in developing countries and especially in SSA, agricultural productivity is so low compared to other sectors. To put in other words, scholars investigate why the agricultural gap between rich and poor countries is so high compared to the non-agricultural sector (Gollin et al., 2014) and how this could explain income growth disparities. This literature gives possible explanations for such a low agricultural productivity: geography (Restuccia and Adamopoulos, 2017), poor measures of agricultural productivity (Herrendorf and Schoelmann, 2015; Gollin et al., 2014), high transports costs (Adamopoulos, 2011; Gollin and Rogerson, 2014), friction related to transportation costs in international trade (Tombe, 2015), the presence of a selection bias (Lagakos and Waugh, 2013) or low use of modern inputs (Restuccia et al., 2008; Yang and Zhu, 2013; Donovan, 2016; Bustos et al., 2016; McArthur and McCord,

[3] They also show that as growth, trade, transport services and agro-processing - considered as manufacturing - are as poverty reducing as agriculture and that finance, business and government services are not.

2017). Among these we focus on the latter: the use of modern inputs such as fertilisers for raising agricultural productivity. Yang and Zhu (2013) show that the price of the modern inputs declines with the size of the non-agricultural sector, which enable them to be adopted by traditional farmers, thus increasing agricultural productivity and freeing agricultural worker to the non-agricultural sector. Therefore in that perspective the level of industrialisation or more precisely the size of the manufacturing sector of a country appears as crucial for driving agricultural modernisation, through the use of modern inputs.

Yet SSA's manufacturing sector is weak and many countries are heavily dependent on their natural resources. Many Sub-Saharan countries face the 'resource curse', largely documented in the literature. Sachs and Warner (1995, 2001) show empirical evidences for a resource curse by studying how natural resources exploitation is associated with a negative growth income growth rate and Van der Ploeg (2011) and Torvik (2009) review why resource is a blessing for some countries while a curse for others. In the literature investigating this, we particularly focus on the Dutch disease phenomenon, which explains how resources exploitation dampens the development of the manufacturing sector. Corden and Neary (1982) show that an unexpected windfall coming from resource discovery or their price increase induces appreciation of the real exchange rate. This makes the country's tradable (manufactured) good less competitive and thus reduces the share of employment in the manufacturing sector, causing possible long term issues on income levels since the manufacturing tradable sector is were technological progress accumulates and experience learning-by-doing (Matsuyama, 1992).

Most studies focus on the impact of natural resources on the manufacturing sector, but only few have assessed the impact of natural resources on agriculture, in a context of increasing dependence on natural resource and a context where most African countries are still at the beginning of their structural transformation with a large agricultural sector and high poverty rates. We suspect that natural resources play an important role on agricultural productivity and thus poverty reduction.

We focus on Sub-Saharan Africa since this region presents a unique path of development and understanding its particular features is important regarding forthcoming challenges. Gollin et al. (2016) show that the region face 'urbanisation without industrialisation' where natural resources are most present, stressing again the importance of resources in their development. Rodrik (2016) argues that the expansion of manufacturing might not play an important role in Africa's development and that the latter might be agriculture or services-led. Given today's economic, social, environmental, political and technological context compared to fifty years ago, it makes sense for Sub-Saharan Africa to follow its own path of development and reveal its potential in a new way. Maybe industrialisation will not play a key role in its development and the latter could still be sustainable, challenging traditional development theories. But given our current knowledge on the importance of industrialisation for agriculture modernisation and the negative link between natural resources exploitation and the size of the manufacturing sector (dutch disease), to what extent can it be problematic for agricultural development in terms of poverty reduction and food security?

3 Analytical framework

We present the theoretical framework of our analysis, that highlights how the rise of the manufacturing sector or natural resources exploitation can decrease the relative price of modern inputs adopted by farmers. Building on Yang and Zhu (2013) and adding natural resources and allowing for trade, we present a small open-economy model in discrete time, where each period represents a year and population is constant. There are two sectors in the economy: sector a for agriculture and sector n for non-agriculture, but we will also refer to it as the industrial or the manufacturing sector. The agricultural good is the numeraire so p_t is the relative price of the industrial good in the world market.

3.1 Consumer preferences

Each consumer, in each period supplies inelastically a unit of work in the labor market and get w_t, the wage. Therefore, the individual's income is $y_t = w_t$ There are two consumption goods: agricultural (a_t) and non-agricultural (n_t). Each agent consumes a fixed amont of agricultural good $a_t = \bar{a}$ and spends its remaining income on the non-agricultural good: $n_t = \frac{y_t - \bar{a}}{p_t}$. As in Yang and Zhu (2013), we mostly focus on firms rather than consumers, since the mechanisms we study are driven by the technologies of production.

3.2 Technologies

Agriculture The agricultural output is produced by a stand-in firm which uses labor L_a, and an intermediate input X_t. The agricultural production function is:

$$Y_{at} = (A_{at} L_{at})^{\gamma} X_t^{1-\gamma}, \tag{1}$$

where $0 < \gamma < 1$, A_a is the worker agricultural productivity and γ denotes the labor share. The firm maximization program is:

$$\text{Max } \pi_a = (A_{at}L_{at})^{\gamma} X_t^{1-\gamma} - w_t L_{at} - p_t X_t$$

Non-agriculture The industrial input is produced by a stand-in firm using labor L_n and natural resources R_t :

$$Y_{nt} = (A_{nt}L_{nt})^{\beta} R_t^{1-\beta}, \tag{2}$$

where $0 < \beta < 1$, A_{nt} refers to the non-agricultural worker productivity and β denotes the labor share. The firm maximisation program is:

$$\text{Max } Y_{nt} = p_t(A_{nt}L_{nt})^{\beta} R_t^{1-\beta} - w_t L_{nt} - r_t R_t$$

3.3 Equilibrium

In this small open economy, we assume balanced trade. Market clearing conditions are:

$$Y_{at} = \bar{a}_t,$$

where

$$\bar{a_t} = \frac{\bar{a}}{(1 + i_t)},$$

and where i_t is the percentage of food imports relative to domestic food production for year t.

$$Y_{nt} = n_t + X_t + E_t,$$

where E_t is the amount of export in non-agricultural goods for year t.

$$\bar{L} = L_{at} + L_{nt}$$

Proposition Let $\widetilde{A}_{at} = X_t^{\frac{1-\gamma}{\gamma}} A_{at}$, at the equilibrium we have:

$$p_t = \frac{\gamma}{\beta} \bar{a}_t^{\frac{\gamma-1}{\gamma}} \widetilde{A}_{at} \frac{L_{nt}^{1-\beta}}{A_{nt}^{\beta} R_t^{1-\beta}} \tag{3}$$

$$w_t = \gamma \widetilde{A}_{at} \bar{a}_t^{\frac{\gamma-1}{\gamma}} \tag{4}$$

$$y_t = \gamma \widetilde{A}_{at} \bar{a}_t^{\frac{\gamma-1}{\gamma}} \tag{5}$$

$$L_{at} = \bar{a}_t^{\frac{1}{\gamma}} \widetilde{A}_{at}^{-1} \tag{6}$$

Structural transformation

In period t, both income per capita (y_t) and agricultural labor share L_{at} depends on $\widetilde{A}_{at}$, as in Yang and Zhu (2013), but we consider that the latter represents agricultural TFP since it encompasses labor productivity and the use of the industrial intermediate input. With an increase of the agricultural TFP, income per capita grows and agricultural labor share declines. Therefore equations 5 and 6 suggest that the economy can experience sustained structural transformation (i.e a decline of the share of agricultural workers) and per capita growth income.

Relative price

The relative price p_t increases with the share of labor and declines with both the manufacturing productivity A_n and natural resources R_t. When the relative price declines, $\widetilde{A}_{at}$ increases since the industrial input X_t becomes less expensive, per capita income increases and agricultural labor share declines. This can be achieved either (i) with industrialization, that is to say an increase of the non-agricultural productivity A_{nt} or (ii) with the exploitation of natural resources R_t.

4 Data and observations

We use data from World Bank and FAO, considering 1991-2016 period for 75 developing countries. The sample is divided into 41 countries of Sub-Saharan Africa, 20 countries of Latin America and Caribbean and 14 Asian countries[4]. We removed small countries with less than 1.5 million inhabitants and dropped Puerto Rico, Somalia and South Sudan because of missing values. We also removed Argentina from the sample because of anormal values.

Most variables come from World's Bank's World Development Indicators (WDI) and main variables are (i) extractive resources rents, as a share of GDP and comprise oil, minerals, coal

[4]Sample composition si available in table 6 in appendix

and natural gas rents, (ii) agricultural productivity per worker, measured as the agricultural value added divided by the number of agricultural workers and expressed in constant 2010 USD, (iii) manufacturing value added share of GDP and (iv) fertilisers inputs, expressed as kilogrammes used per hectare of arable land[5]. Descriptive statistics for SSA are in Table 1, in table 7 for LAC and in table 8 in appendix for Asia.

Table 1: Summary statistics: Sub-Saharan Africa

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Ag. prod. per worker (const. 2010 US$)	1406.764	1755.288	165.812	14476.113	881
Extractive rents (% of GDP)	6.558	11.851	0	59.758	984
Ag. value added share (% of GDP)	27.491	15.257	1.828	93.977	991
Manuf. value added share (% of GDP)	9.605	4.834	0	37.508	939
Ind. value added share (% of GDP)	23.704	12.55	1.882	77.414	987
Services value added share (% of GDP)	44.201	10.657	12.435	93.722	931
Ag. employment share (% of total)	61.528	21.212	4.600	92.842	1066
Manuf. employment share (% of total)	7.141	4.16	0.6	20.6	1066
Ind. employment share (% of total)	11.031	6.593	1.971	42.004	1066
Services. employment share (% of total)	27.441	16.564	5.069	71.929	1066
Urban population growth rate	4.071	1.637	-7.115	17.625	1061
GDP per capita, PPP (const. 2011 inter. $)	2867.806	3462.487	247.437	20919.512	1014
Ag. land (% of land area)	48.212	19.033	8.039	82.671	998
Fertilisers (kg/ha)	11.385	14.397	0	83.127	854
Cereal yield (kg/ha)	1175.252	622.372	152.8	4894	1043
Population density	60.887	75.441	1.78	483.077	1033
Population growth rate	2.628	1.037	-6.185	7.918	1061
Terms of Trade Index	115.583	39.197	21.397	432.926	1007
Government expenditures (% of GDP)	15.025	7.09	2.047	69.543	922
Food imports (% merchandise imports)	17.796	8.531	0.474	62.416	673
Foreign Direct Investment (% of GDP)	4.144	11.224	-82.892	159.719	1008

On average over the period 1991-2016, agricultural productivity per worker was about 2 times higher in Asia (3035.81 USD) and four times higher in LAC (6054.20 USD) compared to SSA (1406.76 USD). Trends for agricultural productivity (figure 7 in appendix) show that the increase was important for Asia, especially since 2000. Increase in agricultural productivity for LAC and SSA was less pronounced.

Figure 1 presents the mean share of employment for each sector for the three regions. There are great disparities between sectoral composition across regions: the share of employment in agriculture in SSA (61%) is almost as high as the share of employment in services

[5]we assembled fertilisers data from FAO for the period 1991-2001 and from World Bank for 2002 to 2016

in LAC (55%). While Asia also presents a high share of employment in agriculture (48%) it presents the same share of manufacturing as LAC (12%), whereas this share accounts for only 7% in SSA. If we consider dynamic trends (figure 2), we see that the decline of employment in the agricultural sector was the largest in Asia (-25 point %) and benefited the three other sectors. Dynamic trends regarding LAC gives us additional information about the large services sector and we observe that this was due to a decline of the manufacturing sector. SSA experienced the same employment share trends yet to a lesser extent since the share in agriculture declined by less than 10 point %. Overall in 2016, SSA remains an agriculture-driven economy, the manufacturing sector is weak and this has not changed much since 1991, compared to the other regions. Similar observations can be made when considering an other variable often use in structural transformation: the value added share (% of GDP) (figure 7 and 8 in the appendix).

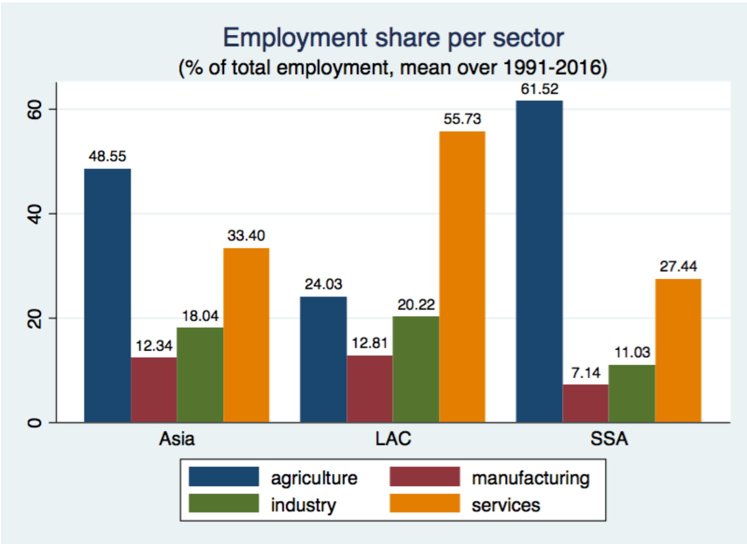

Figure 1: Employment share per sector and per region

All SSA, LAC and Asia exploit natural resources and figure 3 shows that the composition per type of resources[6] is quite similar for each region, yet the economic dependence to natural resources for SSA is higher since extractive resources rents account for 6% of GDP, the double of LAC (3%) and triple of Asia (2%). Considering dynamic trends as presented by figure 4, resources shares follow relatively the same trends except for minerals where the

[6]Total natural resources rents is the sum of extractive rents and forest rents (not represented here but it graphically it is the difference between natural resources and extractive rents); extractive rents is the sum of oil rents, mineral rents, coal rents and natural gas rents

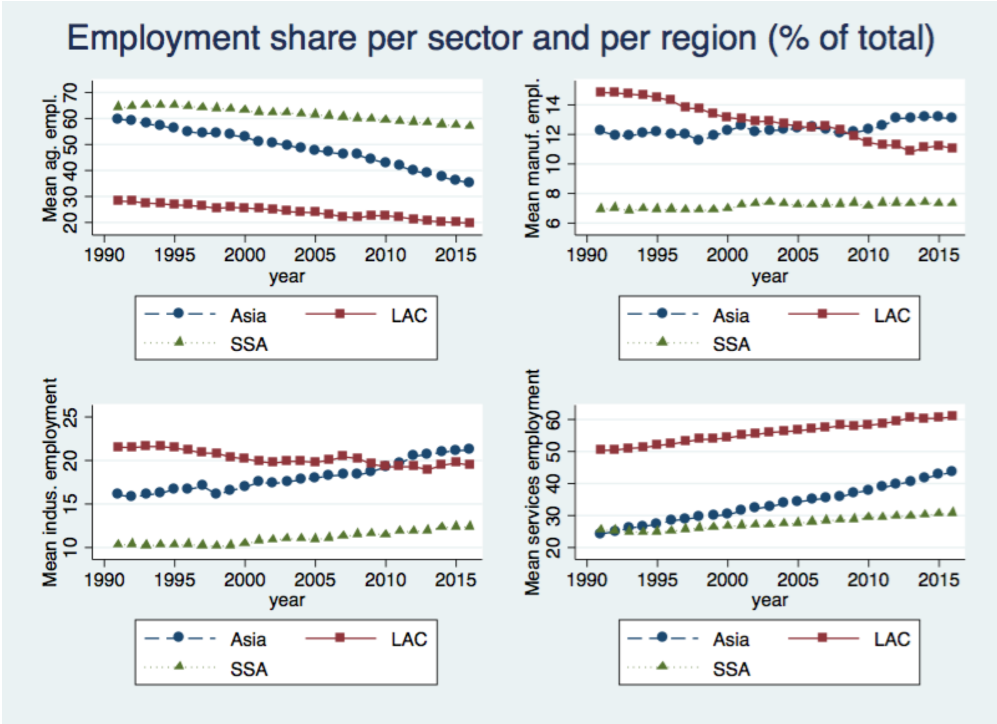

Figure 2: Employment share per sector and per region

relative importance in the economy is almost the same for the three regions until the early 2000s, when the share for minerals sharply increases for SSA. For extractive resources and oil rents, the relatively higher dependence of SSA on natural resources is confirmed for the whole period.

Since the Green Revolution in South Asia in the 60s, modern inputs such as fertilisers are considered as an important way of raising agricultural productivity. Figure 5 and 6 present respectively the mean kilograms of fertilisers per hectare in each region and its trends over 1991-2016. On average, over this period, the use of fertilisers was about 24 times higher in Asia and about 14 times higher in LAC than in SSA. Looking at dynamic trends, we see that the fertilisers use increased in both Asia and LAC but remained steady and at very low level in SSA.

These observations bring important insights for our research question: (i) Regarding the importance of agriculture in the economy, SSA is still at the beginning of its structural transformation and has a weak level of manufacturing (ii) SSA is heavily dependent on its natural resources compared to other regions, (iii) the use of fertilisers in SSA is almost

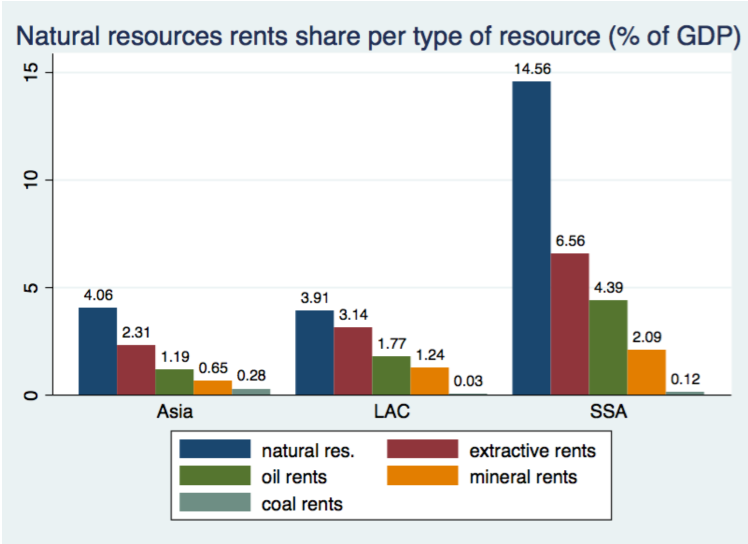

Figure 3: Natural resources rents share per type and per region

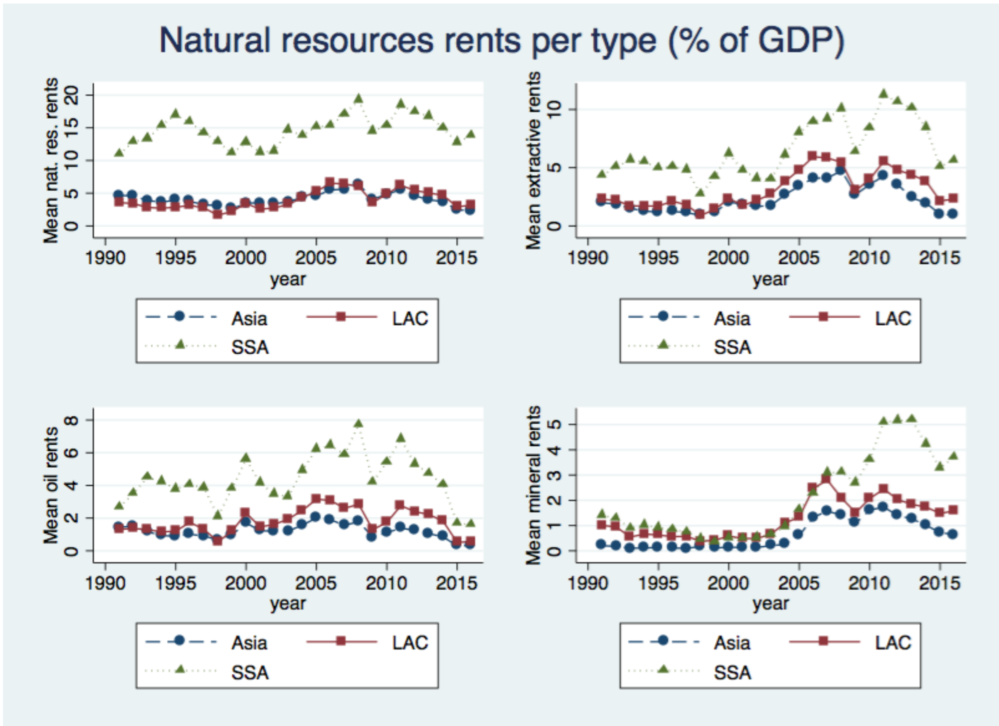

Figure 4: Natural resources rents share per type and per region

inexistant and has shown only little progress in the last three decades. Given these points and the rising macroeconomic role that extractive resources play in Africa's economy on

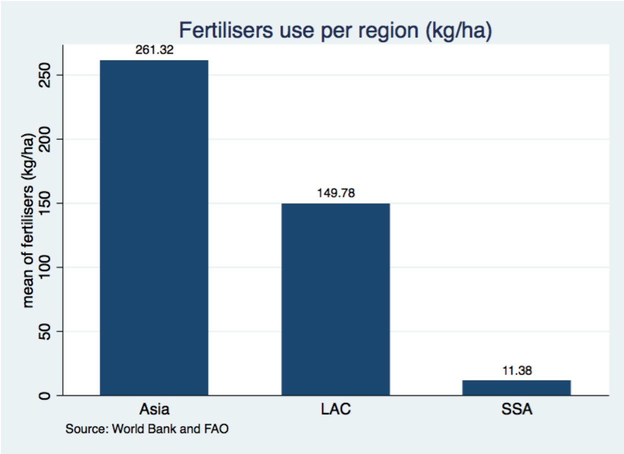

Figure 5: Average fertilisers use (kg/ha) per region: 1991-2016

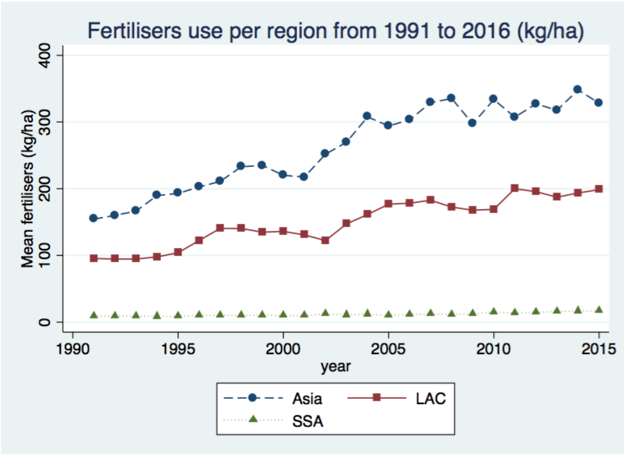

Figure 6: Fertilisers use (kg/ha) per region from 1991 to 2016

the other side, we want to assess to what extent natural resources can impact agricultural productivity.

5 Estimations

We use panel estimates to investigate the link between extractive resources rents and agricultural productivity. We first expect natural resources to have a positive effect on agricultural productivity since large windfall can increase investments (agriculture, infrastructure, education) for example. We find the expected results for LAC and Asia but find that extractive rents share is associated with a small agricultural productivity in SSA. We investigate why the effect is negative in SSA. Our assumption is that poor agriculture modernisation (use of modern inputs such as fertilisers) is due to the small size of the manufacturing sector because of natural resources (dutch disease). Therefore the manufacturing sector cannot play its role and contribute to the decline of modern inputs prices as described in the analytical framework. According to our model, this could not be a problem since natural resources also contributes to decrease the relative price of the manufacturing good, but it seems not to be the case in SSA. It could be that the positive effect resources could have is over-compensated by the negative effect they have on the manufacturing sector. To investigate this, we assess the links between resource exploitation, the level of industrialisation and the use of intermediate inputs (fertilisers). The sample is the same as described previously and covers the period 1991-2016.

5.1 Extractive resources and agricultural productivity worker

First, we apply panel data to investigate the link between extractive natural resources and agricultural productivity in SSA, LAC and Asia separately. The baseline fixed effect specification is constructed as follows:

$$ln[y_{i,t}] = \beta_0 + \beta_1 R_{i,t} + \gamma X_{it} + \alpha_i + u_{it} \tag{7}$$

We observe each variable in 26 periods (from 1991 to 2016). Y_{it} is the agricultural productivity per worker in country i in year t, R_{it} is the extractive resource rents share, X is a vector of controls, including population density, trade dependence, the foreign direct investment (FDI) and terms of trade, α_i is the unobserved country specific effects that determine agricultural productivity and u_{it} is the error term.

Table 2 provides estimation results for SSA. We surprisingly find that resources rents imply a negative impact on agricultural productivity in SSA, whereas the effect is positive for LAC (table 3) and Asia (table 9 in appendix): extractive resources rents share is associated with a greater agricultural productivity. Column (1) provides the unconditional results. For SSA, the coefficient on extractive rents is -0.0054 and strongly significant, implying that a 1% increase in resources rents share is associated with a lower agricultural productivity per worker of 0.54%. To provide a sense of magnitude, if we consider the mean of agricultural productivity for the whole period in SSA: 1406.76 USD, then an increase of extractive rents share of 1% point is associated with an agricultural value added per worker decrease of 7.60 USD. For LAC and Asia, we find the opposite. For example in LAC, the estimated coefficient on resources is greater (0.0258) and strongly significant, implying that a 1% increase in

Table 2: Agricultural productivity and extractive rents - SSA

Dependent variable: agricultural productivity per worker					
VARIABLES	(1)	(2)	(3)	(4)	(5)
Extractive rents	-0.0054***	-0.0058***	-0.0051***	-0.0052***	-0.0076***
	(0.0018)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
Population density		0.0028***	0.0025***	0.0025***	0.0018***
		(0.0005)	(0.0004)	(0.0004)	(0.0005)
Trade openess			-0.0007	-0.0007	-0.0007
			(0.0005)	(0.0005)	(0.0005)
FDI				0.0006	0.0004
				(0.0010)	(0.0010)
Terms of trade					0.0017***
					(0.0003)
Constant	6.8409***	6.6587***	6.7599***	6.7603***	6.6216***
	(0.0142)	(0.0329)	(0.0418)	(0.0420)	(0.0487)
Observations	850	850	811	807	793
R-squared	0.0117	0.0550	0.0554	0.0562	0.0912
Number of country14	37	37	37	37	37

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

resources is associated with higher agricultural productivity per worker of 2.58%. If we consider the agricultural productivity mean over the period 1991-2016 for LAC: 6054.19 USD, this implies that a 1% increase in extractive rents leads to an increase in agricultural productivity of 156.20 USD.

In the remaining columns, we control for several variables. We focus on SSA. Column (2) introduces population density. Agricultural productivity coefficient drops slightly to -0.0058 and population density is significative with a coefficient of 0.0028. The sign of the coefficient of population density is coherent with the fact that a higher density of population could imply the use of more intermediate inputs in order to increase agricultural output.

Column (3) adds trade openness (exports and imports in % of GDP). As a positive impact, openness can allow to import more intermediate inputs that they might not produce or allow for technology transfer. For SSA, we find a negative impact which is surprising but the coefficient is very small and not significative. The coefficient of extractive rents drops to -0.0051.

Column (4) controls for foreign direct investment (FDI). The latter can have a positive impact on agricultural productivity if investment are made in agriculture or infrastructure

Table 3: Agricultural productivity and extractive rents - LAC

Dependent variable: agricultural productivity per worker					
VARIABLES	(1)	(2)	(3)	(4)	(5)
Extractive rents	0.0258***	0.0249***	0.0315***	0.0328***	0.0284***
	(0.0041)	(0.0040)	(0.0044)	(0.0044)	(0.0050)
Population density		0.0035***	0.0041***	0.0034***	0.0038***
		(0.0010)	(0.0010)	(0.0010)	(0.0010)
Trade openess			-0.0036***	-0.0044***	-0.0044***
			(0.0009)	(0.0010)	(0.0010)
FDI				0.0149***	0.0146***
				(0.0051)	(0.0052)
Terms of trade					0.0007**
					(0.0003)
Constant	8.2043***	7.8978***	8.0595***	8.1496***	8.0650***
	(0.0167)	(0.0860)	(0.0949)	(0.0972)	(0.1030)
Observations	496	496	496	471	462
R-squared	0.0771	0.1021	0.1285	0.1494	0.1650
Number of country14	20	20	20	19	19

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

such as roads. The coefficient is positive but very small (0.0006) and not significative and the coefficient of extractive rents is almost not affected (-0.0052).

Column (5) introduces an other critical variable that could influence agricultural productivity, which is the terms of trade.[7] The effect is significantly positive with a coefficient of 0.0017 and the coefficient of extractive rents increases at -0.0076. An improvement in terms of trade can benefit the economy because for the same amount of goods exported it can buy more imports, such as modern intermediate inputs.

5.2 Extractive resources and manufacturing sector

We have seen that extractive resources rents have a negative impact on agricultural productivity in SSA. Our assumption is that this is due to a small level of industrialisation caused by the presence of natural resources. This effect of early de-industrialisation because of natural resources is the core concept of the dutch disease theory. We want to investigate

[7]Terms of trade is the ratio of an index of a country's export prices to an index of its imports prices multiplied by 100. It can be interpreted as the amount of import goods an economy can purchase per unit of export goods.

for the period 1991-2016, if extractive rents share is associated with a decline or not of the manufacturing sector to asses if whether or not we can speak of a dutch disease in SSA. We estimate the same model as previously but now the dependent variable is the size of the manufacturing sector, which represents the level of industrialisation of the country. Is is measured as the manufacturing value added (% of GDP). We control for foreign direct investment (FDI), urbanisation growth rate, trade openness (% of GDP) and government final consumption expenditures (% of GDP).

Table 4: Manufacturing and extractive rents - SSA

	Dependent variable: manufacturing value added				
VARIABLES	(1)	(2)	(3)	(4)	(5)
Extractive rents	-0.0670***	-0.0642***	-0.0638***	-0.0584***	-0.0556***
	(0.0185)	(0.0187)	(0.0188)	(0.0183)	(0.0190)
FDI		-0.0147	-0.0144	-0.0082	-0.0085
		(0.0122)	(0.0122)	(0.0116)	(0.0120)
Urban population growth rate			-0.0592	0.0750	0.0903
			(0.0892)	(0.0854)	(0.0905)
Trade openess				-0.0011	-0.0010
				(0.0057)	(0.0061)
Government expenditures					0.0178
					(0.0293)
Constant	10.0250***	10.0948***	10.3316***	9.7849***	9.4199***
	(0.1556)	(0.1624)	(0.3917)	(0.5356)	(0.6642)
Observations	911	902	902	857	820
R-squared	0.0148	0.0165	0.0170	0.0167	0.0160
Number of country14	38	38	38	38	37

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 provides the results obtained when we estimate this relationship for SSA. Column (1) provides the unconditional results and we find a negative a strongly significative coefficient of -0.067, which supports the dutch disease theory. A 1% increase in extractive resources share is respectively associated with a decline of manufacturing sector by 0.067%. If we consider the mean share of manufacturing in SSA for the whole period: 9.6%, then an increase of extractive rents share of 1% point is associated with a manufacturing share standing at 8.96%.

Column (2) introduces FDI and the coefficient is negative. This result is surprising since we would expect FDI to have a positive impact on the manufacturing sector but the coefficient is not significative. The coefficient of extractive resources slightly decreases. Column (3) adds urbanisation rates. The coefficient is negative but not significative and the coefficient of extractive rents declines at -0.0638. Column (4) introduces trade openness. The coefficient is negative but not significative and the coefficient of extractive rents drops at -0.0584. Column (5) controls for government expenditures. The coefficient is positive but not significative and the coefficient of extractive rents drops at -0.0556.

5.3 Fertilisers and manufacturing value added

We now turn to a key point of our analysis assessing the importance of the manufacturing sector for agricultural modernisation. As showed in our analytical framework, the size of the manufacturing sector impacts the price of the modern inputs. As the manufacturing sector develops, prices of modern inputs decline and the latter are adopted by traditional farmers and agricultural productivity increases. We asses whether we observe this empirically. Considering fertilisers as the modern inputs, we expect to find that the size of the manufacturing sector (value added in % of GDP) is positively associated with the use of fertilisers (kg/ha of arable land). We estimate the same model but now the dependent variable is the use of fertilisers. Our independent variable is the manufacturing value added (% of GDP). We control for population density, terms of trade and foreign direct investment.

Table 5 provides the results obtained when we estimate this relationship for SSA. Column (1) provides the unconditional results and we find a positive coefficient of 0.0203, implying as predicted by the model that the development of the manufacturing sector implies more fertilisers per hectare, yet the coefficient is not significative. Column (2) introduces population density and its coefficient is positive and significative (0.0602). When this control is added, the manufacturing share coefficient sharply increases at 0.1309 but is not significative. Column (3) adds a control for terms of trade. Its coefficient is significative and stands at 0.02. Manufacturing value added share increases to 0.1594 and becomes significative. Column (4) controls for trade openness, coefficient is positive as expected but not significative. Manufacturing share increases slightly. Column (5) introduces foreign direct investment, coefficient is 0.19 and is strongly significative, implying that a 1% increase share of foreign direct investment is associated with an additional 0.19 kilograms of fertilisers per hectare.

Table 5: Fertilisers and manufacturing value added - SSA

Dependent variable: fertilisers					
VARIABLES	(1)	(2)	(3)	(4)	(5)
Manuf. value added	0.0203	0.1309	0.1594*	0.1657*	0.1616*
	(0.0794)	(0.0812)	(0.0834)	(0.0951)	(0.0949)
Population density		0.0602***	0.0533***	0.0467***	0.0439***
		(0.0121)	(0.0124)	(0.0130)	(0.0131)
Terms of Trade			0.0200**	0.0184**	0.0175**
			(0.0084)	(0.0086)	(0.0086)
Trade openess				0.0253	0.0053
				(0.0197)	(0.0219)
FDI					0.1900***
					(0.0691)
Constant	11.5600***	6.3418***	4.3449***	3.0721	4.2333**
	(0.8311)	(1.3266)	(1.6315)	(2.0478)	(2.1065)
Observations	780	780	767	727	720
R-squared	0.0001	0.0327	0.0401	0.0378	0.0493
Number of country14	38	38	38	37	37

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Manufacturing value added coefficient is slightly the same (0.1616), implying that a 1% increase in manufacturing value added is associated with 0.16 additional kilograms of fertilisers per hectare. These results support the idea that the rise of the manufacturing sector is important for agricultural modernisation. But as shown previously, manufacturing development is dampened by extractive resources exploitation and this is a possible explanation for why we find that extractive resources exploitation have a negative impact on agricultural productivity in Sub-Saharan Africa.

6 Conclusion

A large literature focuses on the importance of agriculture for poverty alleviation and understanding the determinants of agricultural productivity. Within this field too little research has assessed the impact of natural resources on agriculture (Dercon and Gollin, 2014). This paper contributes to fill the gap by assessing the impact of extractive resources exploitation on agricultural productivity in Sub-Saharan Africa, through the channel of a manufacturing-led agricultural modernisation. To explain mechanisms at stake and guide our empirical work, a simple two-sector (agriculture and manufacturing) growth model incorporating natural resources is developed. The price of modern agricultural inputs (fertilisers) produced in the manufacturing sector and used in agriculture, declines either with the size of the manufacturing sector (industrialisation) or with natural resources rents (investments in agriculture). Below a certain threshold of the price, modern inputs are then adopted by farmers allowing for agricultural productivity and income per capita to increase.

The empirical panel analysis we conduct allows for three main conclusions: (i) extractive resources have a negative impact on agricultural productivity in SSA but not in LAC and Asia. (ii) We find evidences for the existence of the dutch disease phenomenon in SSA, which gives a possible explanation of the weak manufacturing sector in the region. (iii) We show that the size of the manufacturing sector is important for the adoption of fertilisers. These results suggest as a whole that extractive resources can indirectly impact negatively agricultural productivity because of the small size of the manufacturing size it implies. Positive effects in LAC and Asia suggest that a virtuous use of resources is possible and further research needs to be conducted to understand the underlying mechanisms.

7 References

Adamopoulos, T. (2011). Transportation Costs, Agricultural Productivity, And Cross-Country Income Differences. International Economic Review, 52(2), 489-521.

Adamopoulos, T., & Restuccia, D. (2014). The size distribution of farms and international productivity differences. American Economic Review, 104(6), 1667-97.

Bustos, P., Caprettini, B., & Ponticelli, J. (2016). Agricultural productivity and structural transformation: Evidence from Brazil. American Economic Review, 106(6), 1320-65.

Byerlee, D., De Janvry, A., & Sadoulet, E. (2009). Agriculture for development: Toward a new paradigm.

Christiaensen, L., Demery, L., & Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction?An empirical perspective. Journal of development economics, 96(2), 239-254.

Corden, W. M., & Neary, J. P. (1982). Booming sector and de-industrialisation in a small open economy. The economic journal, 92(368), 825-848.

Dercon, S., & Gollin, D. (2014). Agriculture in African development: theories and strategies. Annu. Rev. Resour. Econ., 6(1), 471-492.

Diao, X., Hazell, P. B., Resnick, D., & Thurlow, J. (2007). The role of agriculture in development: Implications for Sub-Saharan Africa (Vol. 153). Intl Food Policy Res Inst.

Donovan, K. (2016). Agricultural risk, intermediate inputs, and cross-country productivity differences. Unpublished manuscript, University of Notre Dame.

Dorosh, P., & Thurlow, J. (2018). Beyond agriculture versus non-agriculture: decomposing sectoral growth-poverty linkages in five African countries. World Development, 109, 440-451.

Gollin, D., Parente, S., & Rogerson, R. (2002). The role of agriculture in development. American Economic Review, 92(2), 160-164.

Gollin, D., Lagakos, D., & Waugh, M. E. (2014). Agricultural productivity differences across countries. American Economic Review, 104(5), 165-70.

Gollin, D., & Rogerson, R. (2014). Productivity, transport costs and subsistence agriculture. Journal of Development Economics, 107, 38-48.

Gollin, D., Jedwab, R., & Vollrath, D. (2016). Urbanization with and without Industrialization. Journal of Economic Growth, 21(1), 35-70.

Haggblade, S., Hazell, P. B., & Reardon, T. (Eds.). (2007). Transforming the rural nonfarm economy: Opportunities and threats in the developing world. Intl Food Policy Res Inst.

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2014). Growth and structural transformation. In Handbook of economic growth (Vol. 2, pp. 855-941). Elsevier.

Herrendorf, B., & Schoellman, T. (2015). Why is measured productivity so low in agriculture?. Review of Economic Dynamics, 18(4), 1003-1022.

Johnston, B. F., & Mellor, J. W. (1961). The role of agriculture in economic development. The American Economic Review, 51(4), 566-593.

Lagakos, D., & Waugh, M. E. (2013). Selection, agriculture, and cross-country productivity differences. American Economic Review, 103(2), 948-80.

Ligon, E., & Sadoulet, E. (2018). Estimating the Relative Benefits of Agricultural Growth on the Distribution of Expenditures. World Development, 109, 417-428.

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. Journal of economic theory, 58(2), 317-334.

McArthur, J. W., & McCord, G. C. (2017). Fertilizing growth: Agricultural inputs and their effects in economic development. Journal of development economics, 127, 133-152.

OECD et al. (2013), African Economic Outlook 2013: Structural Transformation and Natural Resources, OECD Publishing, Paris, https://doi.org/10.1787/aeo-2013-en.

Restuccia, D., Yang, D. T., and Zhu, X. (2008). Agriculture and aggregate productivity: A quantitative cross-country analysis. Journal of monetary economics, 55(2), 234-250.

Restuccia, D., and Adamopoulos, T. (2017). Geography and Agricultural Productivity: Cross-Country Evidence from Micro Plot-Level Data. In 2017 Meeting Papers (No. 1180). Society for Economic Dynamics.

Rodrik, D. (2016). An African growth miracle?. Journal of African Economies, 27(1), 10-27.

Sachs, J. D., & Warner, A. M. (1995). Natural resource abundance and economic growth (No. w5398). National Bureau of Economic Research.

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. European economic review, 45(4-6), 827-838.

Schultz, T. W. (1953). The economic organization of agriculture (No. HD1411 S43).

Syrquin, M. (1988). Patterns of structural change. Handbook of development economics, 1, 203-273.

Timmer, C. P. (1988). The agricultural transformation. Handbook of development economics, 1, 275-331.

Tombe, T. (2015). The missing food problem: Trade, agriculture, and international productivity differences. American Economic Journal: Macroeconomics, 7(3), 226-58.

Torvik, R. (2009). Why do some resource-abundant countries succeed while others do not?. Oxford Review of Economic Policy, 25(2), 241-256.

Van der Ploeg, F. (2011). Natural resources: curse or blessing?. Journal of Economic Literature, 49(2), 366-420.

World Bank, 2016. Development Indicators.

Yang, D. T., & Zhu, X. (2013). Modernization of agriculture and long-term growth. Journal of Monetary Economics, 60(3), 367-382.

8 Appendix

Table 6: Sample composition per region

Sub-Saharan Africa
Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Dem. rep., Congo, Rep., Cote d'Ivoire, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia,Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe
Latin America and Caribbean
Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela
Asia
Bangladesh, Cambodia, China, India, Indonesia, Korea, Rep., Lao PDR, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam

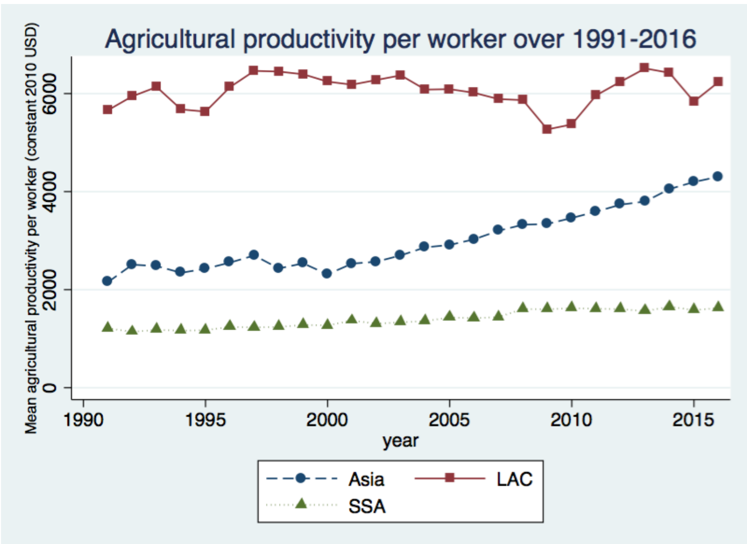

Figure 7: Value added in agriculture per worker per region

Table 7: Summary statistics: Latin America and Caribbean

Variable	Mean	Std. Dev.	Min.	Max.	N
Ag. prod. per worker (const. 2010 US$)	6054.199	8042.610	920.239	52730.741	507
Extractive rents (% of GDP)	3.14	4.862	0	25.376	506
Ag. value added share (% of GDP)	9.925	5.841	2.493	34.22	512
Manuf. value added share (% of GDP)	14.659	3.848	4.586	31.401	512
Ind. value added share (% of GDP)	28.371	7.214	16.294	56.992	512
Services value added share (% of GDP)	53.231	8.744	17.991	73.448	487
Ag. employment share (% of total)	24.038	10.839	3.863	57.474	520
Manuf. employment share (% of total)	12.811	3.367	5.9	23.8	520
Ind. employment share (% of total)	20.222	3.908	8.683	32.996	520
Services. employment share (% of total)	55.74	9.059	33.843	73.614	520
Urban population growth rate	2.218	1.04	0.171	6.196	520
GDP per capita, PPP (const. 2011 inter. $)	9258.976	4668.485	1502.033	22614.394	487
Ag. land (% of land area)	42.754	17.214	16.905	85.486	500
Fertilisers (kg/ha)	149.78	175.605	0.632	980.876	475
Cereal yield (kg/ha)	2741.192	1161.927	826.5	7082.3	520
Population density	89.358	94.952	6.455	393.59	520
Population growth rate	1.445	0.617	-0.064	2.877	520
Terms of Trade Index	112.9	41.95	50.98	321.936	502
Government expenditures (% of GDP)	13.142	5.625	3.114	39.881	516
Food imports (% merchandise imports)	11.536	4.082	2.856	23.413	461
Foreign Direct Investment (% of GDP)	3.375	2.762	-5.007	16.229	492

Table 8: Summary statistics: Asia

Variable	Mean	Std. Dev.	Min.	Max.	N
Ag. prod. per worker (const. 2010 US$)	3035.805	4383.888	384.082	18795.701	343
Extractive rents (% of GDP)	2.31	2.85	0	13.687	347
Ag. value added share (% of GDP)	20.156	11.588	1.928	57.239	353
Manuf. value added share (% of GDP)	19.044	7.179	5.214	32.452	340
Ind. value added share (% of GDP)	31.41	9.237	9.692	48.53	353
Services value added share (% of GDP)	46.231	6.593	33.034	59.598	321
Ag. employment share (% of total)	48.556	21.637	4.904	86.399	364
Manuf. employment share (% of total)	12.346	6.304	0.2	26.9	364
Ind. employment share (% of total)	18.043	8.237	2.76	35.951	364
Services. employment share (% of total)	33.401	14.832	10.229	70.205	364
Urban population growth rate	2.985	1.461	0.363	6.996	364
GDP per capita, PPP (const. 2011 inter. $)	6929.411	6986.31	728.032	35020.412	362
Ag. land (% of land area)	34.866	17.197	7.201	79.281	350
Fertilisers (kg/ha)	261.317	371.26	0	2026.901	325
Cereal yield (kg/ha)	3561.151	1220.479	1301.2	6814.8	364
Population density	255.776	261.166	18.978	1251.837	364
Population growth rate	1.399	0.641	0.212	3.541	364
Terms of Trade Index	98.549	21.899	51.08	222.807	326
Government expenditures (% of GDP)	10.21	3.442	3.46	21.384	334
Food imports (% merchandise imports)	8.513	4.26	2.492	22.462	298
Foreign Direct Investment (% of GDP)	2.684	2.585	-2.757	13.058	349

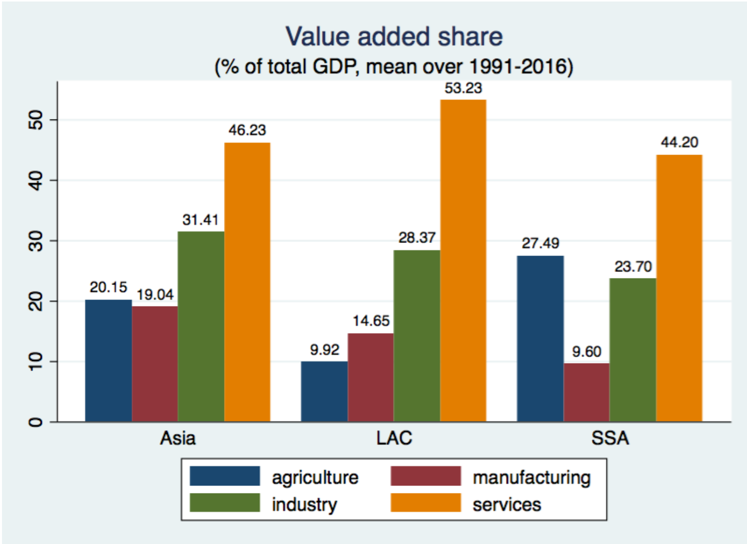

Figure 8: Value added share per sector per region

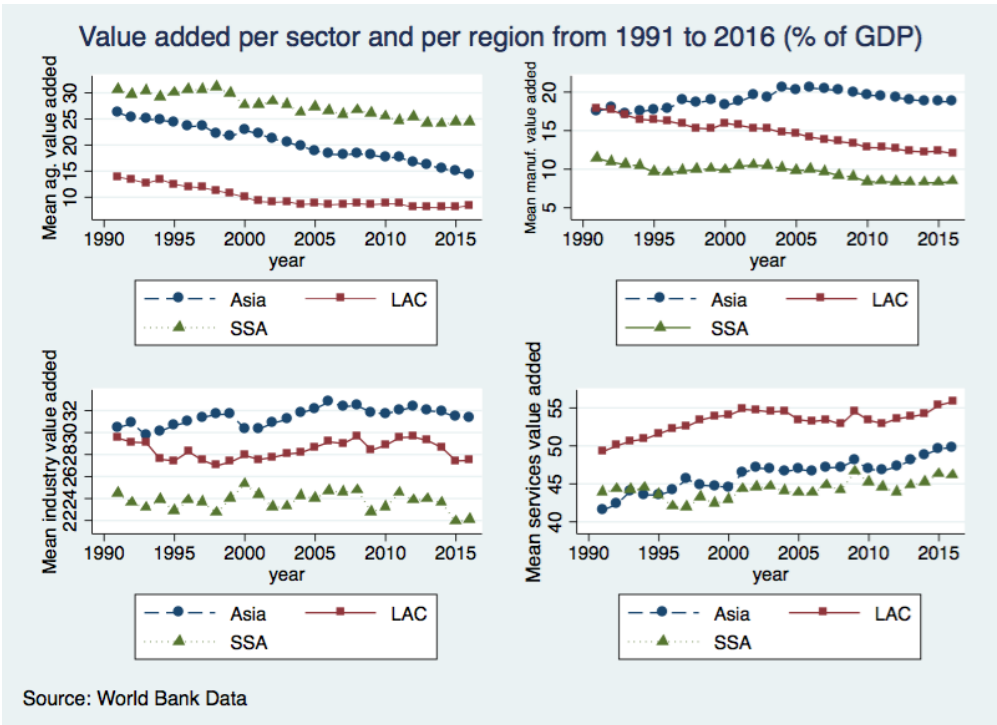

Figure 9: Value added share per sector per region

Table 9: Agricultural productivity and extractive rents - Asia

Agricultural productivity and extractive rents - Asia

	(1)	(2)	(3)	(4)	(5)
	a0	a1	a2	a3	a4
VARIABLES	lagworker	lagworker	lagworker	lagworker	lagworker
Extractive rents	0.0299***	0.0163**	0.0076	0.0063	0.0036
	(0.0093)	(0.0080)	(0.0079)	(0.0080)	(0.0082)
Population density		0.0037***	0.0034***	0.0033***	0.0026***
		(0.0003)	(0.0003)	(0.0003)	(0.0004)
Trade			0.0038***	0.0038***	0.0025***
			(0.0008)	(0.0008)	(0.0009)
FDI				0.0203**	0.0246**
				(0.0089)	(0.0097)
Terms of Trade					-0.0033***
					(0.0011)
Constant	7.2932***	6.3053***	6.1400***	6.1251***	6.7702***
	(0.0273)	(0.0924)	(0.0950)	(0.0965)	(0.2035)
Observations	338	338	338	334	313
R-squared	0.0310	0.2974	0.3483	0.3569	0.3345
Number of country14	14	14	14	14	14

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1