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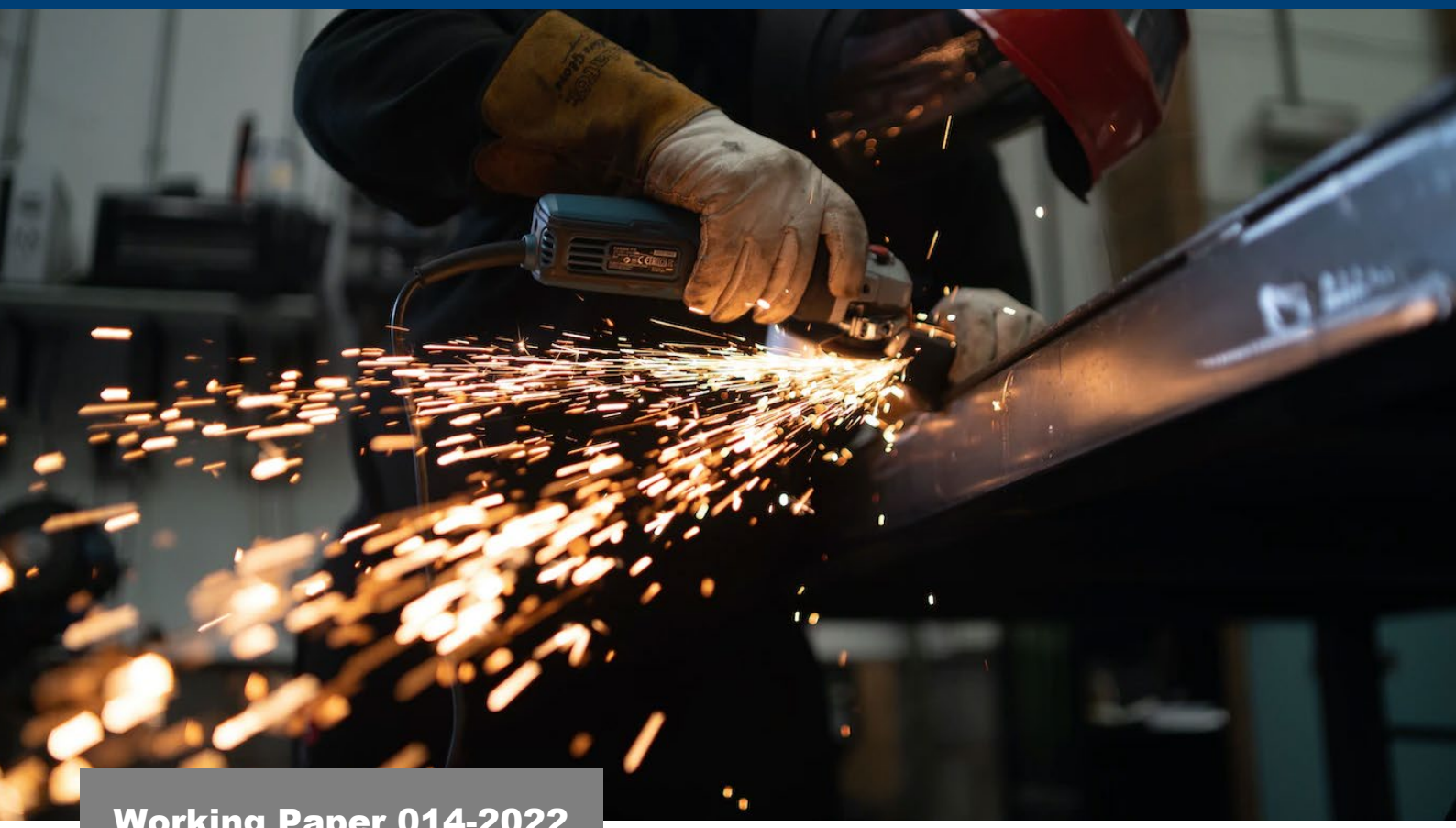

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Made in Africa – How to make local agricultural machinery manufacturing thrive

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Made in Africa – How to make local agricultural machinery manufacturing thrive

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Abstract

Manufacturing can play a key role in sustained economic growth, job creation, and poverty reduction in Africa. Agricultural machinery manufacturing can contribute to driving overall manufacturing, given the large number of gradually mechanizing African farms and the rapidly growing agro-food processing sector. But harnessing these potentials in today's globalized world requires manufacturers to compete with manufacturing powerhouses such as China and India. This paper examines the characteristics, opportunities, and challenges of local agricultural machinery manufacturers in Africa based on a survey among randomly chosen manufacturers (N=386) in Benin, Kenya, Mali, and Nigeria. To further explore the factors and actors being key to the success of manufacturers, the surveys were supplemented with two qualitative methods: 1) 45 net-maps, a participatory appraisal method to map the factors, actors, and bottlenecks affecting the enabling environment of local manufacturing; and 2) 97 key-informant interviews, a method that enables additional in-depth discussions from key stakeholders. These results show that local manufacturers have several comparative advantages, in particular, related to the ability to develop locally adapted machinery, an aspect that is of much higher importance related to agricultural manufacturing than other types of manufacturing. This resonates with the experiences of other world regions where vibrant markets for local machinery were key during agricultural mechanization. The results show that markets for local machinery have also emerged in Africa, driven by small but dedicated entrepreneurs. However, these manufacturers are held back by a range of challenges related to production factors such as finance, human resources, utilities, raw materials, production equipment, and the regulatory environment (i.e., import regulations, testing, and certification). The paper derives important new insights into how to ensure a supportive, enabling environment to help local manufacturers harness their comparative advantages and to make "Made in Africa" the first choice of African farmers and agro-food processors.

Key Words

Manufacturing, agricultural mechanization, structural transformation, industrialization, industrial policy, Africa

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1. Introduction

Manufacturing has been a cornerstone of economic development for most wealthy countries (Haraguchi et al., 2017; Kaldor, 1967; Szirmai et al., 2013) and can play a key role in sustained economic growth, job creation, and poverty reduction in Africa (Chang et al., 2016; Haraguchi et al., 2017; Kaleb et al., 2021; Mijiyawa, 2017; Signé, 2018). Manufacturing will be needed to create jobs for the 220 million youth who will be entering the labor market by 2035 (von Braun & Kofol, 2017), and to reduce extreme poverty, which affects 40% of the population (World Bank, 2022). So far, manufacturing plays only a limited role in Africa (Nnyanzi et al, 2022; Page et al., 2016), contributing 12% of the GDP and 11% of the employment in Sub-Saharan Africa (World Bank, 2022). Signé (2018) describes this as a "missed opportunity for economic transformation" (p. 1). There are now high hopes to harness this "missed opportunity" and signs of a "manufacturing renaissance" (e.g. Kaleb et al, 2021; Kruse et al., 2021). The African Union envisions a central role for manufacturing in its Agenda 2063 (Bouchene et al., 2021; Signé, 2018) and the African Development Bank has chosen "Industrialise Africa" as one of its five priority areas[1].

Agricultural mechanization offers a unique potential for African manufacturing and the question of how to harness this potential will be the focus of this paper. Agricultural mechanization involves the use of mechanical power across the agro-food system, including farm production, post-harvest handling, storage, and processing (Daum & Kirui, 2021). African agro-food systems are the least mechanized in the world (FAO & AUC, 2018; Daum, 2022; Diao et al., 2020). For example, only 10% of crop farmers use tractors (FAO, 2020). But mechanization is high on the African development agenda (FAO, 2020) and there are signs of rapid mechanization in some areas, due to farming system evolution and structural change (Daum, 2022; Diao et al., 2020). Diao et al. (2020) argue that African mechanization is no longer held back by lacking demand but, now, rather by supply-side constraints. Mechanizing Africa's 85 million farms (Lowder et al., 2021) will create a large demand for the products of agricultural machinery manufacturers such as tractors, power tillers, plows, rippers, planters, shellers, threshers, and mills, among others. Additional demand will come from the agro-food processing sector, which is one of Africa's fastest-growing economic sectors, driven by a growing and increasingly wealthy urban population (Bughin et al., 2016; Malabo Montpellier Panel, 2018). While agricultural mechanization creates large opportunities for manufacturing, harnessing these potentials in today's globalized world requires African manufacturers to compete with (low-cost) imports from today's manufacturing powerhouses such as India and China, as further discussed below.

1 https://www.afdb.org/en/high5s (Accessed 27/10/2022)

Historical research shows that local manufacturers have played a key role in today's mechanized countries (e.g., Biggs & Justice, 2021; Binswanger, 1986; Daum et al., 2018). While not all of today's mechanized countries have started to manufacture large types of machinery such as combined harvesters and tractors, and attempting so may not be needed in today's globalized world, many have developed industries for "light manufacturing" such as tractor implements and processing technologies, which require more local adaptation (Biggs & Justice, 2015; Biggs & Justice, 2021; Binswanger, 1986; FAO & AUC, 2018). Compared to global actors, local manufacturers in the vicinity of farmers can be much better positioned to develop engineering solutions that are adapted to local agro-ecological conditions (Biggs & Justice, 2015; Biggs & Justice, 2021; Binswanger, 1986; FAO & AU, 2018; Mrema et al., 2018; Samarakoon, 2011). In Asia, where mechanization is more advanced than in Africa, vibrant local manufacturing markets have played a key role (Belton et al., 2021; Biggs & Justice, 2015; Diao et al., 2020). These markets have become an important source of rural employment and are associated with positive spillover effects for rural development (Biggs & Justice, 2015). However, in Africa, this sector has largely been neglected (Samarakoon, 2011). In an influential framework on agricultural mechanization in Africa, the Food and Agriculture Organisation and the African Union Commission have therefore identified "building sustainable systems for manufacture" as a top ten priority (FAO & AUC, 2018).

Several studies provide valuable insights into African manufacturing. These studies have often taken a macro-economic perspective, comparing African manufacturing vis-à-vis other world regions (Diao et al., 2021; Kruse et al., 2021), other sectors (Mensah et al., 2018), and over time (Kruse et al., 2021; Nguimkeu & Zeufack, 2019; Rodrik, 2016). Other studies have focused on the institutional framework conditions for African manufacturing (e.g., Singé, 2018), sometimes focusing on specific constraints such as access to finance, transportation infrastructure, and electricity (e.g., Abdisa & Hawitibo, 2021; Azolibe & Okonkwo, 2020; Fowowe, 2017; Nnyanzi et al., 2022). These challenges are also frequently assessed by the World Banks Enterprise Surveys (World Bank, 2021). Such studies and assessments are also of high relevance to understanding the situation of agricultural machinery manufacturing, but agricultural machinery manufacturers face a range of unique opportunities and challenges. To our knowledge, despite their vital role in manufacturing and agricultural transformation, there is no comprehensive study specifically analyzing the characteristics, opportunities, and challenges of African agricultural machinery manufacturers.

The objectives of this research were to explore the characteristics, opportunities, and challenges for local agricultural machinery manufacturers in Africa, taking four countries,

Benin, Kenya, Mali, and Nigeria, as case-study countries. The study aimed to not only attest to opportunities and challenges but to also understand which factors and actors are key to harnessing opportunities and addressing challenges. For this, the study combined a set of quantitative and qualitative methods. To understand the opportunities and constraints experienced by local manufacturers, a quantitative survey with randomly chosen local manufacturers (N=386) was conducted. To further explore the factors and actors that are key to the success of manufacturers, the surveys were supplemented with two qualitative data collection methods: 1) net-maps, a participatory appraisal method that helps to map the factors, actors, and bottlenecks affecting a certain outcome; and 2) key informant interviews, a method that enables in-depth discussions with key stakeholders. The qualitative data collection methods were applied to a wide range of different stakeholders, such as knowledge- and skills-building organizations, policymakers and regulatory bodies, end-users (i.e., farmers and agri-food processors), financial institutions, and development partners, among others. The qualitative data collection allowed us to holistically explore the entire "innovation system", that is, the "network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance" (World Bank 2006, p.vi). The innovation system framework captures all "actors and factors that co-determine innovation" (Klerkx et al., 2012, p. 457), making it highly suitable to understand potential bottlenecks and to develop policy recommendations, in this case, on how to create a conducive business environment for local agricultural machinery manufacturers and make them thrive vis-à-vis global competitors.

2. Literature Review

Scholars focusing on African manufacturing typically distinguish four periods: 1) a period of heavy state support and protectionist policies, 2) a period of prolonged crisis, 3) a period of state withdrawal, 4) and a period of rising global competition. After independence, manufacturing grew in most countries during the 1960s and 1970s due to heavy government support and protectionist policies (e.g., Mijiyawa, 2017; Signé, 2018). In agricultural manufacturing, the situation was more mixed, with many countries importing machinery such as tractors to modernize farming, foreclosing the development of local manufacturers (FAO & AUC, 2018). In the 1980s and 1990s, manufacturing was affected by the oil price and commodity price crisis, unfavorable exchange rates, and declining public support due to quickly accumulating public debts (Signé, 2018). In the 1990s, most countries had to undergo structural adjustment reforms to address the public debt crises, leading to the liberalization of trade and the privatization of state-owned enterprises, and a decline in industrial policymaking. Singè (2018) has described this as a "restart" for African manufacturing, but other scholars have emphasized the drawbacks. Unsupported and unprotected, many manufacturers could not survive, leading to an "erosion of the industrial base of the continent" (Mijiyawa, 2017, p. 150). In agricultural manufacturing, this period was characterized by the closure of several factories producing agricultural machinery and implements (FAO & AUC, 2018). Since the 2000s, manufacturing has been affected by fierce competition due to globalization and the rise of new manufacturing powerhouses (Mijiyawa, 2017; Page et al., 2016). In agricultural manufacturing, such competition comes in particular from Asia (i.e., India, and China), but also from Latin America (i.e. Brazil), Eastern Europe, and Turkey (FAO & AUC, 2018). Consequently, some scholars have argued that Africa is experiencing "premature de-industrialization" (Rodrik, 2016), and many governments have returned their focus from manufacturing to agriculture as an "engine" for pro-poor growth (Mijiyawa, 2017).

More lately, several scholars have refuted the notion of de-industrialization (Kaleb et al., 2021; Nguimkeu & Zeufack, 2018), finding signs of an African "manufacturing renaissance" (Kruse et al. 2021). Since the 2010s, the contribution of manufacturing to Sub-Saharan Africa's GDP rose by 3 percentage points to around 12%, and the share of employment rose by 1 percentage point to around 11% (World Bank, 2022). The "manufacturing renaissance" appears to be driven by small, often informal, manufacturers who mostly produce for domestic markets and do not achieve high productivity but absorb much labor (Diao et al., 2021; Kruse et al., 2021). Manufacturing's share of GDP varies widely across Sub-Saharan Africa: from 2% in Liberia and Sierra Leone to 33% in Gabon (World Bank,

2022); and 70% of African manufacturing value-added comes from South Africa, Egypt, Nigeria, and Morocco (Singé, 2018). Agricultural machinery manufacturing sectors equally differ across Africa. As noted by Houmy et al. (2013), “in some countries, only the simplest of hand tools are made mostly in the artisan (blacksmith) sector; in other countries, sophisticated manufacturing facilities exist” (p.27).

Several studies have analyzed the opportunities and challenges of African manufacturing, revealing constraints related to human capital, financial capital, infrastructure, and the policy environment, among others, which can raise production costs and undermine competitiveness. Regarding human capital, African manufacturing is believed to benefit from an “abundance of low-cost, underemployed labor” but much of this labor lacks “skills and efficiency” (Signé, 2018; p. 7). Primary education completion rates have risen to 70% but they are still 20 percentage points below the world average and only around 35% complete secondary education (World Bank, 2022). Moreover, “learning outcomes have been persistently poor” (Arias et al., 2019) and employers often find knowledge- and skills-building efforts to be too theoretical (Kirui & Kozicka, 2018). According to the Enterprise Surveys of the World Bank (2021), 16% of manufacturing firms in Sub-Saharan Africa identify an “inadequately educated workforce as a major constraint”. Access to financial resource capital is another major challenge (Abdisa & Hawitibo, 2021; Dihn et al., 2012; Fowowe, 2017), which 38% of manufacturing firms identify “as a major constraint” and 23% as their “biggest obstacle” (World Bank, 2021).

Poor infrastructure heavily affects the production costs, competitiveness, and marketing opportunities of African manufacturers (Dihn et al., 2012; Singé, 2018). Calderón et al. (2018) found that Sub-Saharan Africa “ranks at the bottom of all developing regions in virtually all dimensions of infrastructure performance” (p. 2). Across Africa, manufacturing firms struggle with patchy, unreliable, and costly energy access (Abdisa & Hawitibo, 2021; Calderón et al., 2018; Nyanzu & Adarkwah, 2016; Signé, 2018). 77% of all manufacturing firms regularly experience electrical outages - on average 9 outages per month, each lasting on average 6 hours (World Bank, 2021). Firm managers estimate losing 8.5% of annual sales due to power outages (World Bank, 2021). 53% of the firms use expensive backup generators, which produce 30% of the electricity used (World Bank, 2021). Electricity costs are thrice as high compared to other developing regions (Signé, 2018). 53% of all firms consider electricity problems as a severe or very severe obstacle (Geginat & Ramalho, 2018). Transportation infrastructure also remains a challenge. Railroad networks are few and poor (Calderón et al., 2018), suffering from a “spiral of neglect and decay” (AFB, 2015). According to Calderón et al. (2018), Sub-Saharan Africa is the only region witnessing declining road densities over the last two decades. Illustratively, only 16% of all roads are

paved, undermining road use during rainy seasons (Calderón et al., 2018; Meijer et al., 2018; Singé, 2018). Africa also struggles with “substantial gaps” in ports (Singé, 2018). According to the Enterprise Surveys of the World Bank (2021), 24% of manufacturing firms in Sub-Saharan Africa identify transportation as a “major constraint”.

Regarding the policy environment, there are many positive developments – as well as some persisting challenges. Trade barriers within Africa have been reduced due thanks to the African Continental Free Trade Area (AfCFTA), among other initiatives. Trade barriers to global markets have been reduced, too, but trade policies continue to undermine the availability and quality of raw materials and production equipment as well as affect their costs in some countries (Signé, 2018). The costs of doing business have declined thanks to reform efforts in many countries, but firms continue to be affected by “notoriously high levels of corruption and bureaucratic restrictions” (Signé, 2018,p. 9). According to the Enterprise Surveys of the World Bank (2021), 39% of manufacturing firms in Sub-Saharan Africa identify corruption as a “major constraint” and 7% as their “biggest obstacle”. Next to bureaucracy and corruption, manufacturers can also suffer from macroeconomic instability (Signé, 2018). Nnyanzi et al. (2022) highlight the importance of improving governance for the sector, that is rule of law, regulatory quality, and government effectiveness, among others. After years of neglect, some countries have begun to support the building of industries and the transformation of informal craftmanship to (small-scale) manufacturing. However, in many countries, this is not the case, or industrialization efforts focus only on a few large flagship projects.

There are no comprehensive studies on the specific challenges faced by agricultural manufacturing industries in Sub-Saharan Africa. However, the FAO has published several reports on agricultural mechanization in Africa where the plight of local manufacturers is also touched upon. Daum & Birner (2017) shed some light on manufacturing in Ghana, and Sims et al. (2012) explore manufacturing in the context of machines and tools for Conservation Agriculture in Southern Africa. Houmy et al. (2013) draw a distinction between state-owned manufacturers and private manufacturers, which can be formal and industrial or informal and artisanal. State-owned manufacturers are often heavily supported with subsidies, tax exemptions, and prioritization in public tenders, giving them an advantage over private companies (Houmy et al., 2013). According to Houmy et al. (2013), state-owned manufacturers achieve high product qualities, but their products are expensive due to “high overheads, cumbersome purchasing procedures, and low production efficiencies” (p. 27). Private agricultural manufacturing is undermined by a business environment that is characterized by lacking access to electricity and finance, lacking standards and testing, and lacking knowledge and skills development related to both technical and economic

aspects, as well as by high taxation, and high import duties on raw materials (as compared to low import duties on finished goods) (Birner & Daum, 2017; Houmy et al., 2013; Sims et al., 2012). Informal and artisanal manufacturers – who are often located in rural areas and close to farmers - are significant sources of simple, affordable, and locally adapted machines and tools, but quality standards are poor and variable and working conditions can be bad (Birner & Daum, 2017; FAO & AUC, 2018). All types of manufacturers struggle to compete with low-cost imports from global manufacturing powerhouses such as China and India, as well as from development partners and government projects importing machinery in bulk from abroad (FAO & AUC; 2018).

3. Research countries, sampling, and methods

3.1. Research Countries

This research was conducted under the project “Program of Accompanying Research for Agricultural Innovation” (PARI).[2] Of the 14 countries covered by PARI, four were chosen for this study: Benin, Kenya, Mali, and Nigeria. These countries are located in West and East Africa and are characterized by different geographical and agroecological conditions as well as economic characteristics and business environments (see Table 1). Table 1 shows that manufacturing contributes between 7-13% of GDP and 6-18% of employment. Nigeria has by far the largest manufacturing sector in terms of value added (55 billion US$), followed by Kenya (7 billion US$), Benin, and Mali (both between 1-2 billion US$). Of the four countries, Kenya consistently ranks best in the quality of the business environment indicators; manufacturers in all the other countries struggle with a relatively poor enabling environment (see Table 1). Manufacturing is high on the policy agenda of all four countries. For example, in Kenya, manufacturing is on the government’s “big four agenda” (GOK, 2017).

[2] See https://research4agrinnovation.org/

Table 1. Characteristics of the four case study countries

	Benin	Kenya	Mali	Nigeria	Year, Source
Economic Characteristics					
Population (million)	12	54	20	206	2020, World Bank (2021)
GDP/capita (US$)	1,291	1,838	858	2,097	
Manufacturing Sector					
Share of GDP (%)	10	8	7	13	2020, World Bank (2021)
Value added (Billion US$)	1.5	7.2	1.2	54.8	
Share employment (%)	18	6	8	12	
Agricultural Sector					
Share of GDP (%)	27	35	36	24	2020, World Bank (2021)
Share employment (%)	38	54	62	35	
Use of tractors	1% of land	2-13% of farms	1% of farms	4% of farms	2014-2019, Daum et al. (2021)
Business Environments					
Ease of Doing Business (Rank, of 190)	149	56	148	131	2020, World Bank (2021)
Enabling Business of Agriculture (0-100)	33	65	34	49	
Global Competitiveness Index (Rank, of 137)	120	91	123	125	2017/2018, World Economic Forum (2018)
Higher Education and Training	114	97	119	116	
Availability of financial services	119	58	120	102	
Transport Infrastructure	120	62	116	128	
Quality of electricity supply	131	94	116	136	
Irregular payments and bribes	130	94	131	124	

3.2. Study sites, sampling, and methods

The goal of this study was to obtain a holistic understanding of the opportunities and challenges for local manufacturing of machinery and equipment for agro-food systems, and the factors and actors affecting the success of such domestic manufacturers. To obtain such a holistic understanding, multiple methods were used – a survey among manufacturers, net-maps sessions, and key-informant interviews - and interacted with a wide range of stakeholders. Table 2 provides an overview of the data collection methods and sample sizes in the four countries. In each country, 3-4 local administrative regions (zones, districts, or counties, depending on the country) were chosen that are dominated by agricultural production and characterized by the presence of local agricultural manufacturers (see Table 2).

Table 2. Sampling framework

	Regions	Manufacturers	Net Maps		Key Informants
			Sessions	Participants	
Benin	ADH4, ADH5, ADH7	50	16	62	30
Kenya	Kiambu, Kisumu, Nairobi, Nakuru	94	13	78	25
Mali	Koulikoro, Segou, Sikasso	151	6	50	12
Nigeria	Kaduna, Niger, Oyo	91	10	109	30
Total		**386**	**45**	**299**	**97**

To obtain insights into the perspectives of local manufacturers, we have conducted a quantitative survey among 386 manufacturers in the four countries (see section 2.2.1.). To obtain insights from other stakeholders, 45 qualitative participatory net-map sessions were conducted (see section 2.2.2.). These sessions were conducted with stakeholder groups such as manufacturers as well as end-users (farmer and processing industry associations), raw materials providers, regulatory bodies, financial institutions, and knowledge and skills-building institutions, among others. The net-maps sessions helped to identify the complex network of factors, actors, and bottlenecks affecting the business environments of manufacturing, that is, the agricultural innovation system (World Bank 2006). The net-maps session also served to identify respondents for the 97 key-informant interviews (see section 2.2.3). The interviews allowed to further discuss some of the aspects that affect the success of manufacturers. All data were collected between June and December 2020. Informed consent was obtained from all study participants. Using different methods and talking to a wide range of stakeholders helped to triangulate the data collected (as recommended by Bitsch, 2005).

3.2.1. Survey

For the study, 386 manufacturers were surveyed. For this, lists with all manufacturers in specific regions were generated with the help of local organizations.[3] From these lists, sub-sets of manufacturers were randomly sampled. In Benin, 50 manufacturers were sampled. In Kenya, 120 manufacturers were sampled, however, due to Covid-19-related restrictions, only 94 manufacturers could be interviewed. In Nigeria, 91 manufacturers were interviewed. In Mali, 151, manufacturers were interviewed.

[3] In Benin, this list was generated with the Territorial Agency for Agricultural Development, the Ministry of Industry, and the Ministry of Agriculture, among others. In Kenya, we generated this list with the County Agricultural Office and the Kenya National Bureau of Statistics (KNBS). In Nigeria, we worked with the Agricultural Machineries and Equipment Fabricators Association of Nigeria (AMEFAN) and the Federal Institute of Industrial Research (FIIRO). In Mali, the list was generated by the respective regional associations of the “Fédération Nationale des Artisans du Mali”.

3.2.2. Net Maps

To understand bottlenecks in the agricultural innovation system affecting the success of agricultural manufacturers, 45 focus group discussions were conducted using net maps, a participatory appraisal method (Schiffer, 2007). Net-maps help to understand the complex networks of factors and actors affecting a certain outcome, relying on visualization and group interaction (Schiffer, 2007). Visualization helps to engage the participants and to structure the discussion. Group interaction allows drawing on the combined "swarm intelligence" of the participants and enables constant cross-checking by other participants, sparking discussions. Net-Maps have been used in previous studies, for example, to understand challenges associated with the provision of veterinary services in Uganda (Ilukor et al., 2015), livestock vaccination campaigns in Zambia (Lubungu and Birner, 2018), and social safety net programs in India (Raabe et al., 2010). Daum and Birner (2017) have used net-maps to understand the governance challenges of agricultural mechanization in Ghana. In this study, net-maps were mostly conducted as part of focus group discussions. The net-map sessions were typically conducted with 6-12 respondents, but smaller groups in some cases due to COVID-19-related health restrictions or security concerns, e.g., in Mali. The net-maps sessions were conducted in a standardized sequence of five steps. In the first step, participants were asked the following questions

1) Who are the actors and factors that affect the success of manufacturers?

The mentioned actors and factors were written on post-its with different colors (representing different categories of actors and factors) and placed on a large sheet of paper. In the second step, participants were asked the following question:

2) How are these actors and factors linked among each other and with the manufacturers, and how do they affect the success of manufacturers?

The linkages were indicated on a large sheet of paper, connecting the different actors. Different types of linkages (e.g., flows of information, money, and goods/services) were indicated with arrows using different colors. In the third step, participants were asked the following question:

3) What is the degree of influence of the different actors and factors on the success of manufacturers?

The perceived level of importance of the actors and factors was assessed on a scale from 1-10 and indicated on the paper sheet using either stars or checker pieces to visualize the

level of influence once a consensus was reached. In the fourth step, participants were asked the following question:

4) Where are bottlenecks and challenges between the actors affecting the success of manufacturers?

The bottlenecks were indicated on the large sheets of paper using red arrows. In the fifth step, participants were asked to discuss the following questions, based on the final net map:

5) How can the identified bottlenecks be addressed?

In the last step, respondents discussed how to minimize the identified bottlenecks. During all steps, the participants were asked to elaborate on their opinions (e.g., on why and how the mentioned actors and factors affect the manufacturing). The stakeholders discussed these questions collectively, revealing important insights.

2.2.3. Key Informant Interviews

Across the four African countries, 97 key-informant interviews were conducted with actors who were identified as being key to the success of manufacturers (see Table 3). Respondents were selected based on the net-maps sessions and the literature review and identified using snowball or chain-referral sampling. For the interviews, interview guidelines were used using semi-structured and open-ended questions.

Table 3. Overview of qualitative data collection

Key informant interviews	Benin	Kenya	Mali*	Nigeria	Total
Policymakers	6	4	1	3	**14**
Knowledge/skills-building organizations	7	11	2	6	**26**
Financal institutions	3	1	1	4	**9**
Manufacturer organizations	9	4	3	10	**26**
Customer organizations (i.e. farmers, processors)	5	5	3	5	**18**
Development partners	0	0	2	2	**4**
Total	**30**	**25**	**12**	**30**	**97**

Note: * Not all planned key informant interviews could be completed due to security considerations.

4. Results

4.1. Business characteristics

4.1.1. Owners and business background

Table 4 provides an overview of the characteristics of the business owners. Most manufacturers were motivated to pursue their profession because of aspiration (65%) or because of family tradition (24%). Almost all manufacturers are male, typically between 35 and 55 years old. Most manufacturers have received only limited formal training. In Benin and Mali, most manufacturers have no formal education or only primary education. In Kenya and Nigeria, there is a much higher share of manufacturers with secondary education (39% and 30%) and university degrees (30% and 41%). Only 38% have participated in any type of business training, which may explain why only 44% of businesses use accounting systems (see Table 7). The high share of manufacturers who own farmland (70%) is noteworthy, suggesting a strong familiarity with the needs of local agriculture.

Table 4. Owner and business background

	Benin	Kenya	Mali	Nigeria	Average
Motivation					
Aspiration	89	71	36	65	65
Family tradition	6	11	62	17	24
No alternatives	4	12	2	11	7
Others	0	5	0	7	3
Gender					
Male	100	91	100	99	97
Female	0	9	0	1	3
Age					
Below 35	19	14	15	9	14
35 - 45	32	46	30	32	35
45 - 55	40	30	36	37	36
55 - 65	6	9	15	16	12
Above 65	2	0	3	7	3
Educational level (highest)					
None	4	0	31	4	10
Primary	52	25	51	11	35
Secondary	20	39	3	30	23
University	10	30	4	41	21
Vocational	6	5	5	7	6
Others	8	0	7	6	5
Educational background					
Agriculture	10	-	28	40	26*
Engineering	84	-	42	44	57*
Business	0	-	4	2	2*
Others	6	-	26	13	15*
Farmland Ownership					
Yes	57	82	74	65	70
No	43	18	26	35	31
Business training					
Yes	49	30	28	44	38
No	51	70	72	56	62

Notes: *Except Kenya.

Figure 1 shows the decades during which the sampled enterprises were originally founded. The majority of Malian and Nigerian manufacturers were founded in the 1990s and 2000s, whereas most manufacturing businesses in Benin and Kenya were founded in the 2010s. Table 5 shows that manufacturing companies are mostly private (94%). 65% of the manufacturers surveyed are formally registered (but only 45% in Nigeria) and 59% are part of an association (but only 16% in Kenya).

Figure 1. Years of foundation

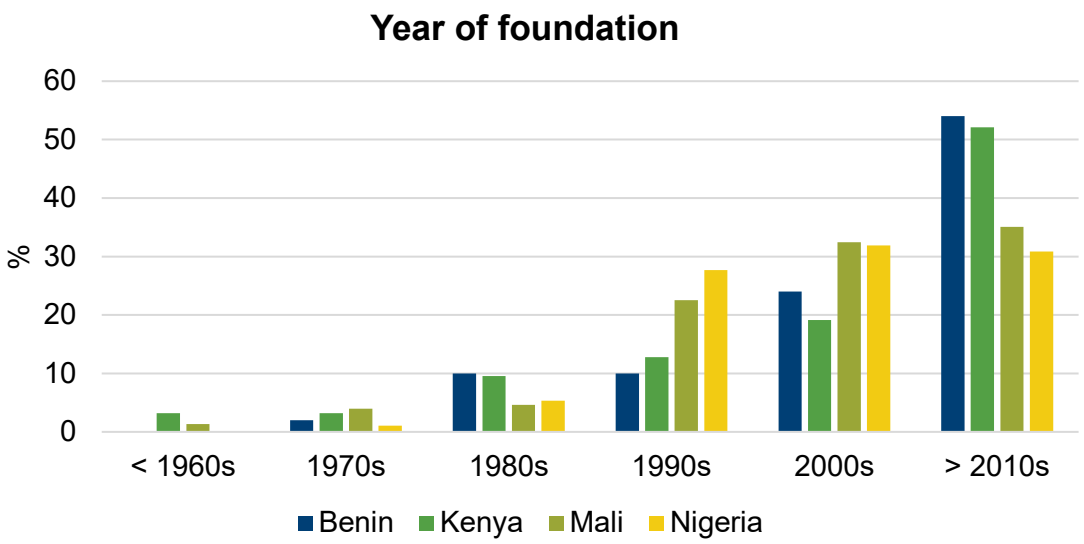


Table 5. Business Characteristics

	Benin	Kenya	Mali	Nigeria	Average
Type					
Private (domestic owner)	96	89	96	96	94
Private (foreign owner)	2	6	1	0	2
Shareholder Company	0	1	1	4	2
Public	2	3	0	0	1
Public-Private	0	0	3	0	1
Others	0	0	0	0	0
Formal registration					
Yes	58	79	76	45	65
No	42	21	24	55	36
Association					
Yes	78	16	85	57	59
No	22	84	15	43	41
Business location					
Settlement < 10,000 people	8	29	21	3	15
Settlement 10,000-50,000 people	36	14	21	14	21
Settlement 50,000-100,000 people	22	23	24	45	29
Settlement > 100,000 people	34	34	35	37	35

4.1.2. Production characteristics and trends

Agricultural manufacturers mostly produce machinery for crop production and post-harvest handling (44%) and crop processing (24%), but many manufacturers also produce machinery for other sectors such as livestock production, construction, and transportation (see Table 6). In Kenya, which has significant meat and dairy industries, a particularly large share of the machinery produced is for the livestock sector (27%). Among the most common types of machinery produced are mills, threshers, and shellers in Benin, choppers, mills, threshers, and shellers in Kenya, plows, rippers, harrows, carts and trailers, planters, and

seeders in Mali, and mills, threshers, and shellers in Nigeria. An average manufacturer in our sample produces around 17 threshers and shellers, 13 mills, 12 tractor attachments for land preparation (e.g. plows, harrows, or rippers), and several other types of equipment, per year. 14% of all manufacturers produce machinery that can be powered with renewable energy, in particular pumps and dryers.

Table 6. Types of machinery produced

	Benin	Kenya	Mali	Nigeria	Average
Shares of machines produced (%)					
Crop production, post-harvest handling	22	35	71	48	44
Crop processing	33	25	8	31	24
Livestock production, processing	7	27	6	8	12
Horticulture production, processing	2	3	4	0	2
Forestry	6	0	2	2	3
Construction, transportation, and others	30	10	9	11	15
Number of machines sold (last 12 months)					
Threshers, shellers	12,2	16,2	11,2	27,4	16,8
Mills	15,2	22,6	4,4	9,4	12,9
Plows, harrow, rippers	0,8	4,8	39,7	2,7	12,0
Choppers	0	21	0,6	1,0	5,7
Carts, trailers	0,3	1,8	19,5	0,1	5,4
Seeders, planters	2,6	1,3	13,1	2,5	4,9
Irrigation equipment	0	7,5	5,8	0	3,3
Tractors, incl. two-wheel-tractors	0,4	3,5	2,4	0,50	1,7
Generators	0	4,8	0,8	0	1,4
Others	22,1	22,7	5,8	1,1	12,9
Machines with renewable energy					
Yes	8	17	9	21	14
No	92	83	91	79	86

58% of the manufacturers across the four countries stated to produce only on-demand and 29% stated to produce both on-demand and regularly (see table 7). Respondents cited market risks (61%) and lack of capital (56%) as reasons for on-demand production. Another stated reason was the ability to customize machinery to customers' preferences (36%). The downside of on-demand production is that it reduces production efficiency and raises costs vis-à-vis importers, who typically produce on a large scale using an assembly line production system. Further, customers must wait for their machinery to be produced and delivered. Customers also typically need to make a down payment before the actual production begins, which helps manufacturers to minimize market risks and source the required capital for production. Upfront payments are particularly common in the cases of larger and motorized equipment. For customers, the necessity of making a substantial down payment constitutes a risk factor as they cannot see the final product yet, unlike when purchasing finished, imported machinery. The risk is exacerbated as only 27% of all

manufacturers reported being subject to some kind of third-party testing. The production designs of machinery are typically based on the ideas of the manufacturers themselves (68%) or are copied from other manufacturers and importers (67%). 39% of the manufacturers stated that the design of products is influenced by the ideas and preferences of customers. 62% of the manufacturers stated that they do their own research and development. On average, 42% of all profits are re-invested into the manufacturing business.

Table 7. Production characteristics

	Benin	Kenya	Mali	Nigeria	Average
Production mode					
On-Demand	56	62	53	59	58
Mixed	38	15	32	31	29
Regularly	6	23	15	10	13
Reasons on-demand (%, multiple)					
Market risks	70	65	-	49	61*
Lack of capital	48	51	-	51	56*
Customer specifications/preferences	44	33	-	34	37*
Others	12	6	-	3	7*
Down payment					
Yes	96	84	98	85	91
No	4	16	2	15	9
Production design (multiple)					
Own development	72	72	59	80	68
Copy from other manufactures	84	55	63	66	67
Customers	52	54	10	64	39
Employees	0	10	3	8	4
Government bodies	0	0	5	2	2
Others	0	11	0	8	4
Own research and development					
Yes	68	53	74	54	62
No	32	47	26	46	38
Distribution of profits (%)					
Private use	55	60	-	53	56*
Invest in business	39	40	-	47	42*
Others	6	0	-	0	2*
Third-body testing					
Always or mostly	32	28	29	19	27
Never or rarely	68	72	71	81	73
Accounting system					
Always or mostly	36	77	23	39	44
Never or rarely	64	23	77	61	56

Notes: *Except Mali.

4.1.3. Marketing, customers, and competition

Table 8 gives some insights into the types of customers of local agricultural machinery manufacturers and table 9 provides insights related to their main competitors. Mirroring the

insights on the type of types of equipment produced, agricultural machinery manufacturers mainly sell to farmers (64%), particularly small-scale (>2ha) (33%) and medium-scale (2-15ha) (30%) farmers, as well as processing companies (11%). Most manufacturers' customers are from their region (80%) and the share of customers from abroad is very small (2%). Manufacturers mostly acquire customers through word-of-mouth advertisement – a reputational mechanism that may help to ensure some quality standards, and social media. In the case of social media, there are large differences between the four countries, with 61% of manufacturers in Kenya using this type of marketing, but only 5% in Mali. Showrooms and displays (e.g., in front of the shop), farm shows, and machinery exhibitions are also important. Some manufacturers work with dealers. Traditional marketing channels such as newspapers, radio, and TV are of limited importance. 43% of all manufacturers grant credits to customers, allowing them to pay off the products over time, a practice that is particularly common in Mali, where 87% of the manufacturers do this. Manufacturers stated that customers can pay in cash (96%) or using bank transfers (40%). In Kenya and Nigeria, mobile money transfer is also common, a mechanism that is absent in the two Francophone countries.

Table 8. Customers and Marketing

	Benin	Kenya	Mali	Nigeria	Average
Customers					
Smallholder farmers (<2ha)	15	48		36	33*
Medium-scale farmers (2-15ha)	12	21	91§	27	20*
Large-scale farmers (>15ha)	18	8		7	11*
Processing companies	22	7	4	22	11
Cooperatives	15	1	4	1	5
Public organizations and programs	13	5	0	4	5
Transporters and retailers	4	5	0	3	3
Others	1	5	1	0	2
Location of customers					
Within region	73	70	94	85	81
Outside region, within country	24	27	4	14	17
Outside country, within Africa	3	4	2	1	2
Advertisement (multiple)					
Word-of-mouth	74	68	76	69	72
Social media	30	61	5	27	31
Showroom and display	46	37	3	19	26
Shows and exhibitions	14	27	10	30	20
Dealer network	12	21	10	12	14
Newspapers, radio, TV	8	16	15	7	12
Others (e.g. competitions, extension)	2	12	3	15	8
Point of sales (multiple)					
Workshop	100	93	-	81	91*
Dealer network	4	39	-	13	19*
Others	0	6	-	6	4*
Customer credits					
Yes	26	37	87	24	43
No	74	63	13	76	57
Payment mode (multiple)					
Cash	100	93	99	91	96
Bank	42	53	0	66	40
Mobile	0	64	1	33	25
Others (e.g., in-kind)	8	7	3	2	5
Warranty					
All or mostly	98	77	61	86	80
None or mostly not	2	23	39	14	20
After-sales services					
Yes	98	86	71	84	85
No	2	14	29	16	15
Unmet Demand					
Yes	91	74	97	73	84
No	9	26	3	27	16

Notes: § In Mali, the questionnaire did not distinguish between different categories of farmers. *Except Mali.

The perceived main competitors are domestic (72%), with manufacturers perceiving their advantages vis-à-vis importers as being related to quality (75%), price (44%), local adaptation (36%), after-sales services (35%), and reputation/trust (18%) (see table 9). 85% of the manufacturers stated that they provide some form of after-sales service and 80% provide a warranty (see table 8).

Table 9. Competition

	Benin	Kenya	Mali	Nigeria	Average
Main competitors					
National	77	71	66	76	72
International (inside Africa)	1	1	15	2	5
International (outside Africa)	15	27	16	21	20
Public imports	7	1	3	1	3
Perceived advantages over importers (multiple)					
Quality	78	77	78	66	75
Price	46	34	52	44	44
Local adaptation	50	18	47	32	37
Availability	12	37	57	38	36
After-sales services	46	46	23	25	35
Trust, reputation	14	22	13	23	18
Others	4	6	11	1	6

4.1.4. Human resource management and staff characteristics

Table 10 shows some descriptive statistics related to human resource management and employees. Manufacturers have 7,9 employees on average, with manufacturers in Kenya employing the most staff (12,2). Employees typically have a primary (40%) or secondary education (43%). In Kenya and Nigeria, there is a high share of employees who have a university degree (43% and 43%, respectively) or have completed vocational training (22% and 27%, respectively). 71% of all manufacturers provide “on-the-job”-training, which typically lasts around three years. In 37% of the cases, this is part of a more formal collaboration with vocational training centers where trainees obtain additional knowledge and skills. In the other 63% of the cases, this training is more informal, and trainees are only trained by the manufacturers themselves. On average, manufacturers had 9,9 trainees in the last three years, 41% of whom received some salary.

Table 10. Human resource management and staff characteristics

	Benin	Kenya	Mali	Nigeria	Average
Number of employees					
2020	4,6	12,2	7,0	7,8	7,9
2017	2,9	15,3	6,6	7,3	8,0
Education of employees					
None	36	7	16	10	17
Primary	48	23	60	30	40
Secondary	32	60	14	66	43
University	8	43	3	32	22
Vocational	4	22	3	27	14
Others	0	2	4	7	4
On-the-job training					
Does manufacturer train trainees? (%)	58	79	74	74	71
Number of trainees (last 3 years)	11,1	11,2	3,9	13,4	9,9
Lengths (in years)	3,7	3,2	3,3	3,3	3,4
Share receiving payment (%)	0	55	64	45	41
Monthly payment, if paid (US$)[#]	-	105,1	82,7	79,2	89,0*
Collaboration with a vocational training center (%)	45	28	40	36	37

Figure X. Note *Kenya, Mali, and Nigeria only. [#] Conversion from local currency to US$ as per 31/12/2020.

4.2. Business environment

An enabling business environment is key to the success of local agricultural manufacturers. Figure 2 gives a representation of the mixed impression of the business climate across the four sampled countries. Manufacturers' perception of the business environment is mostly positive in Kenya and Mali, and more negative in Benin and Nigeria. However, it is important to note that manufacturers' judgments are subjective and do not necessarily enable cross-country comparisons.

Figure 2. Business climate

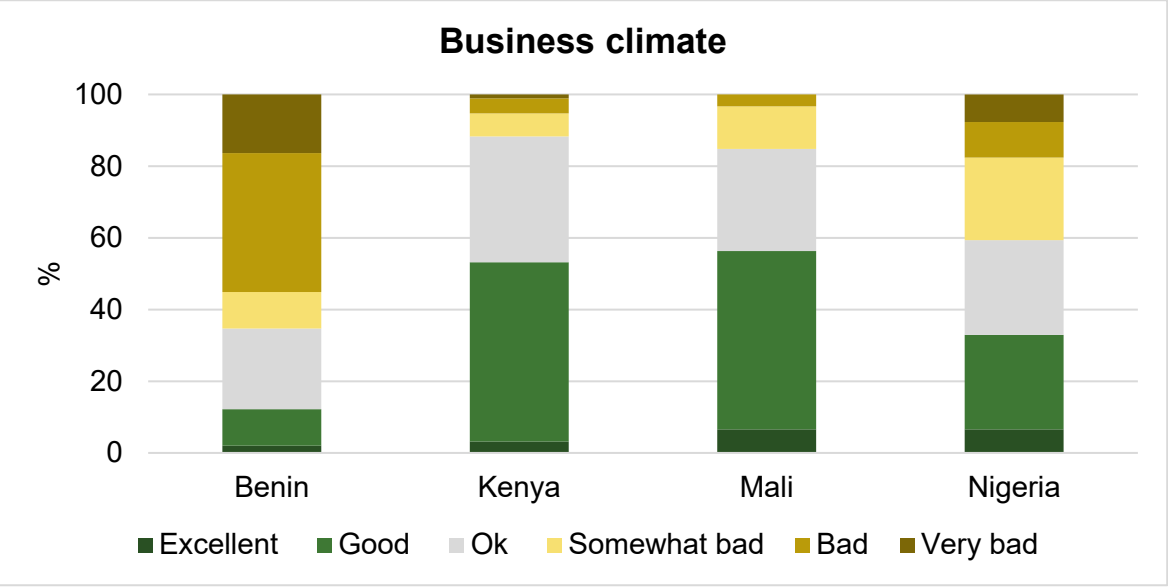


Figure 3 shows the top 10 business constraints that manufacturers perceive as undermining their business. Some of the major constraints are related to the access and costs of finance, access and costs of electricity (i.e., in Mali and Nigeria), and access and costs of inputs (i.e. raw materials for production). There are also constraints related to market risks, the access and costs of machinery for production, and unfavorable import policies, among many others (see Figure 3).

Figure 3. Top 10 business constraints

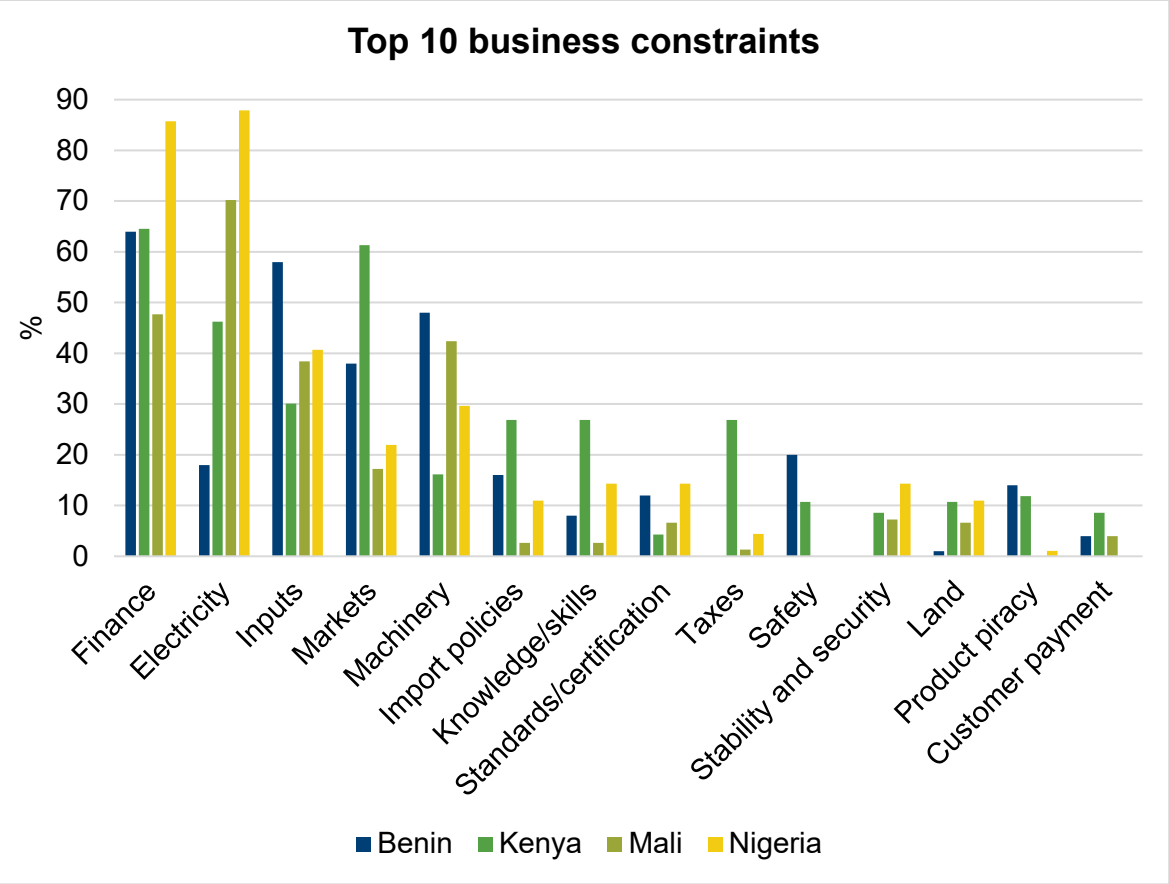


Table 11 provides some more insights into the aspect of finance, which was identified as the main business constraint in Benin and Kenya and the second largest business constraint in Mali and Nigeria (where access and costs of electricity were ranked as slightly larger constraints). Overall, very few manufacturers across the four countries used external capital. Those who used external capital in the last three years, that is between 2017 and 2020, obtained it primarily from microfinance institutions (11%), commercial banks (10%), and friends and family (6%). 26% of all manufacturers sampled in the four countries applied for formal credit in the last three years. As reasons for not applying for formal credit, manufacturers cited tedious application processes, preferences for other sources, perceived lack of success chances, and strict repayment schedules, among others (such as lacking interest and fears of becoming indebted). Of those that did apply for formal credits, the vast majority (87%) received the credits. The low application rates and high

approval rates may be due to manufacturers underestimating their chances of receiving credits and/or a form of self-selecting bias, where only manufacturers with high chances to receive credits make the effort to apply for it.

Table 11. Capital and Finance

Finance	Benin	Kenya	Mali	Nigeria	Average
Finance sources (multiple, last 3 years)					
Microfinance	14	0	20	11	11
Commercial bank	2	26	7	5	10
Friends, family	2	4	11	8	6
Moneylenders	2	1	1	1	1
NGOs, faith-based organizations	2	0	1	0	1
Others	0	1	7	1	2
Credit application (last 3 years)					
Yes	24	30	31	20	26
No	76	70	69	80	74
Credit application accepted					
Yes	91	100	78	78	87
No	9	0	22	22	13
Credit conditions					
Annual interest rate	8,3	12,4	10,6	17,3	12,2
Reasons for non-application (multiple)					
Tedious process	57	24	14	32	32
Prefer other sources	21	52	20	15	27
No chance	32	8	18	37	24
Strict repayment schedule	19	39	12	8	20
Interest rate	3	0	2	8	3
Others (i.e. no interest, fear)	35	23	40	4	26

Table 12 provides more detailed insights into some aspects of the enabling environment. In Benin and Kenya, most manufacturers have access to the electricity grid, this aspect was thus not perceived as a large business constraint (see Figure 3). This contrasts with Mali and Nigeria, where the share of manufacturers connected to the grid is lower (81% in Nigeria; 76% in Mali), and where electricity from the grid is also costly and unreliable, undermining production processes (see also Figure 3). On average, manufacturers are relatively satisfied with the knowledge and skills of trained job market entrants. Across the four countries, only 26% stated that they were “not really” or “not at all” satisfied (Benin stands out with 64% dissatisfaction). Almost all manufacturers (89%) who stated that they were “somehow”, “not really”, or “not at all” satisfied with job market entrants, suggested that the knowledge and skills-building domain should incorporate more practical and applied elements (see Table 12). Table 12 also shows the entry barriers that manufacturers have experienced when starting their business; although their businesses are of various ages,

as detailed in Figure 1. The main entry barriers are related to a lack of capital (74%), production equipment (37%), and raw materials (28%).

Table 12. Business environment

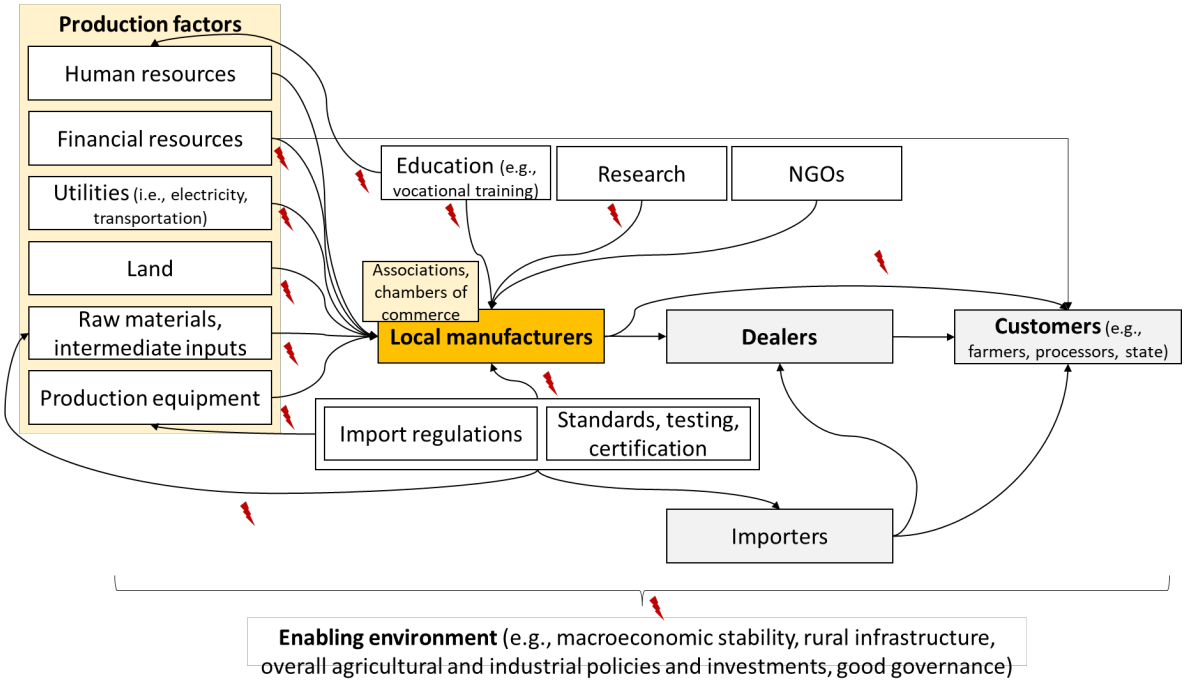
	Benin	Kenya	Mali	Nigeria	Average
Direct government support (last three years, multiple possible)					
Knowledge and skills	36	11	1	13	15
Loans and credits	2	5	2	9	5
Free or subsidized production equipment, industrial land, etc.	4	1	4	7	4
Others	2	1	3	0	2
None	58	83	90	73	76
Access to the electricity grid					
Yes	96	98	76	81	88
No	4	2	24	19	12
Satisfaction with job market candidates (with degrees)					
Very much	2	46	22	20	22
Mostly	6	23	47	44	30
Somehow	28	19	19	18	21
Not really	14	7	7	13	10
Not at all	50	4	4	5	16
Need for education system change[§] (multiple possible)					
More practice	91	100	82	-	89*
Better teachers	5	5	11	-	7*
More theory	0	5	11	-	5*
Updates curricula	0	5	5	-	3*
Others	0	10	0	-	3*
Entry barriers when starting a business (multiple possible)					
Lack of capital	76	89	47	82	74
Lack of production equipment	24	44	50	29	37
Lack of raw materials and parts	40	38	3	30	28
Lack of land	2	22	11	11	12
Lack of knowledge and skills	4	20	5	10	10
Lack of electricity	2	2	2	24	8
Others	14	58	18	27	29

Notes: [§] Only asked to respondents who answered the question on satisfaction with job market candidates (with degrees) as somehow, not really, or not at all. * Except Nigeria.

The results from the net-maps and interviews are illustrated in the stylized agricultural innovation system (see Figure 4), which reveals that a wide range of different factors and actors influence the success of manufacturers. In all countries, a large share of manufacturers is self-organized in associations and chambers of commerce to advocate for their interests and coordinate activities. These organizations have been described as central for local manufacturers, however, they are not always well-funded, as was noted in the case of Mali. Figure 4 also shows that there are various bottlenecks between key components of the agricultural innovation systems, which can undermine the success of

local manufacturers. Some of these challenges were already clear from the above-shown quantitative insights from the manufacturer surveys, but others are new.

Figure 4. Stylized agricultural innovation system of manufacturers



Six input factors are key to the production process of manufacturing: finance, labor, electricity, land, raw materials, and machinery. Access to finance is needed for manufacturers to overcome their capital constraints, and it is also important for other actors such as suppliers and customers. However, mirroring the insights from the manufacturers themselves, the qualitative insights also showed that access to finance is often a challenge for manufacturers: credit applications are demanding and tedious, interest rates are high and repayment schedules are ill-adopted to the characteristics of the agricultural sector. Labor is another key factor. While labor is generally available, the available knowledge and skills may be limited, highlighting the importance of the education system. All countries have some initiatives to improve knowledge and skills in manufacturing, such as the Programme Nationale de la Formation Professionnelle in Mali, however, such initiatives do not appear to reach the majority of manufacturers and their employees. In all countries, informal and formal “training-on-the-job”-models have emerged (see also Table 10). Formal models in partnership with vocational training centers are more common among larger manufacturers, but some smaller manufacturers also offer this type of training. Formal technical education was often seen as being too theoretical by both key informants and experts, and the manufacturers themselves (see Table 12). Importantly, it is not only the laborers who need sufficient knowledge and skills but also the manufacturers themselves. While key informants and experts often stated that some manufacturers have high levels of knowledge and skills,

the knowledge and skills of the majority of manufacturers were said to be limited, as the following quotes from Benin and Nigeria suggest:

"If we build the capacity of local artisans, I think they can do a lot more. Currently, they are left to their own devices. They need support."

"Most manufacturers are blacksmiths trained on the job and do not have advanced technical training."

"There is a need for us to be trained to get the required skill to do the job effectively."

Next to engineering knowledge and skills, current and future manufacturers also need knowledge and skills related to business management (see also Table 4).

In all countries, the research system was identified as a potentially key factor for the success of local manufacturers. Research is necessary to develop locally adopted engineering solutions. Developing locally adapted machinery has been identified as a potentially large comparative advantage of local manufactures, as further discussed below, however, these opportunities are not fully harnessed in countries where the public research system was weak. In all countries, the research system was said to be poorly funded and to fail to follow the latest developments, as illustrated by the following quote from Benin and Mali:

"The state must necessarily finance research and development so that researchers can develop machines adapted to the processing of our local products"

"Most machines built by manufacturers are adaptations from outside; we don't have our design. Therefore research should be funded to create our makes".

Utilities were identified as key bottlenecks in the agricultural innovation system (see also Figure 3). In many countries, transportation infrastructure is poor, raising the costs of production and undermining the marketing of products overall longer distance and abroad. Moreover, particularly in Mali and Nigeria, electricity is not only costly but also unreliable, which can heavily undermine production processes. Some manufacturers use generators to become independent from the public electricity grid, but this raises the costs of production. Industrial land and machinery for production are other key constraints, as identified by the manufacturers themselves and in the key informant and expert interviews, as the following quote from Mali shows:

„Manufacturers need advanced equipment to make their manufactures as beautiful as imported ones"

Lastly, the access and costs of raw materials and parts can be problematic, as noted by key informants and experts in all countries. It was stated that there can be quality problems with raw materials and parts for production.

Despite these challenges, local manufacturers are typically very confident that they have a comparative advantage vis-à-vis importers due to superior product quality, among others (see also table 9). The qualitative interviews with representatives of farmers and from the food and beverage processing sectors reveal a more mixed picture. Some respondents indeed found that local manufacturers have an advantage over importers related to quality as well as prices and after-sales services (i.e., repairs and spare parts availability). One aspect that was frequently highlighted as a comparative advantage was the ability to tailor machinery to the specific local agro-ecological conditions, as the following quote from Benin, Kenya, and Nigeria highlights:

"Machines made outside do not meet our realities. (…) To guarantee the future of this sector, we [need to] manufacture machines adapted to our reality".

"Locally manufactured products are built for local purpose and hence superior".

"The machines imported to the country are not suitable for our environment, though they are of good material. Therefore, we always take them to the local fabricators for modification around here before using them"

But many key informants and experts also emphasized challenges, suggesting that outdated machinery design, lacking standards and testing, poor quality raw materials, lacking production equipment, lacking knowledge and skills, among others, can translate to products of limited quality, as the following quote from Benin and Mali suggests:

"Despite the efforts that manufacturers make, people still complain about the maintenance and quality of local equipment. (…) They don't have the engineering skill at hand."

"Our machines are robust, but they are not performing as imported ones. Used materials will never give good quality machines, they should be trained to select appropriate materials for making machines."

In the absence of standards, testing, and certification of locally produced goods, customers often opt for imported machinery to reduce their risks. The need for testing and certification was a strong theme in the interviews with the stakeholder from the agricultural innovation system and is reflected in the following quotes from Benin and Nigeria:

"There should be an organization that controls and certifies locally manufactured machines."

"The machines certification is not done at all. Nobody has come to our area to check the products we are producing. Though we were told in training that there are organizations in charge in the country but they have never come to our area."

Another disadvantage of local manufacturers is that they mainly produce only on-demand, which means they cannot benefit from the efficiency gains related to assembly-line types of production. In many cases, on-demand manufacturers require a substantial down payment before starting production, which constitutes a risk for customers. Local manufacturers can also be disadvantaged because finished products come with lower import duties and taxes as compared to raw materials needed for local manufacturers. Moreover, it was remarked that government and development projects often favor imports. For example, respondents in Mali stated that government and development partners' projects supporting mechanization often prefer imported equipment – even if this is more expensive – because importers can deliver larger quantities in a shorter time. Lastly, key informants and experts also discussed problems related to the enabling environment. In addition to problems related to education, research, and electricity already discussed above, this includes rural infrastructure and problems related to the costs of doing business, in particular the enforcement of contracts. Most contracts (e.g., between manufacturers and raw material- and parts-providers, or manufacturers and their customers) are informal. The lack of legal options in case of non-compliance with the agreed terms of the transaction is associated with high transaction costs, as the following quotes from Benin and Mali suggest:

"During collaborations, some actors did not respect the terms of contract (…), which are, in most cases, verbal, thus creating a climate of lack of trust between these different actors".

"Because of illiteracy, many manufacturers don't respect the terms in the contract such as dimension and time to deliver. This creates disputes among manufacturers and customers."

5. Discussion and policy implications

Local manufacturing can contribute to economic development in Sub-Saharan Africa, enabling job creation and poverty reduction. Agricultural machinery manufacturing can play a key role in driving overall manufacturing development, given the huge number of gradually mechanizing African farmers and the demand from the rapidly growing agro-food processing sector. Harnessing this potential requires African agricultural manufacturing to compete with imports from manufacturing powerhouses such as China and India. This paper suggests that local manufacturers have several comparative advantages, particularly the ability to develop locally adapted machinery, an aspect that is of much higher importance related to agricultural manufacturing than other manufacturing sectors (see also Biggs & Justice, 2015; Biggs & Justice, 2021; Binswanger, 1986; FAO & AUC, 2018; Mrema et al., 2018; Samarakoon, 2011). Another comparative advantage is the ability to facilitate access to spare parts and repair services (FAO & AUC, 2018). Markets for local machinery have emerged in all four case studies countries, however, manufacturers face a range of challenges related to production factors such as finance, human resources, industrial land, utilities (i.e., electricity), raw materials, and production equipment, as well as challenges related to the overall regulatory environment, resonating with the challenges faced by the overall manufacturing sector in Africa (see section 2). The results make clear that more efforts are needed to generate a supportive environment for local manufacturers.

Policies and investments to create a supportive environment for local agricultural manufacturing played a key role in many of today's mechanized countries (see also Binswanger and Donovan, 1987; Daum et al., 2018), including, more lately, many Asian countries (Bhattarai et al., 2020; Diao et al., 2020). So far, despite some increasing public support, the results of this paper show that not enough is being done to support local agricultural machinery production. While infant-industry and industrial protection arguments have re-emerged in African policy debates (Economist, 2020; Page et al., 2016), a lot can be done in terms of industrial policies and investments to generate a level playing field for local manufacturers without resorting to such more drastic measures – as shown by the "Enhancing the Quality of Industrial Policies (EQuIP)" project (GIZ & UNIDO, 2022). Not all potential policy instruments can be discussed here, and it should be clear that there are no blueprints, but some key areas for needed policy action can be distilled from the results of this paper. Importantly, while public actors have typically played a key role in creating the necessary support functions needed for agricultural manufacturers (Binswanger and Donovan, 1987), private and third-sector organizations can also play an important role (see

also Daum et al., 2018; FAO & AUC, 2018), and strengthened collaboration among the three sectors can help to choose, design, and implement the right policies and investments.

Improving the enabling environment for local agricultural manufacturing requires both general policies and investments, as well as policies and investments that are specifically tailored to the sector. General policies and investments relate to macroeconomic conditions concerning credit markets and exchange rate policies, electricity networks and transportation infrastructure, and primary, secondary, and tertiary education, among others (see also Bhattarai et al., 2020; Binswanger & Donovan, 1987; Dihn et al., 2012). There is also a need for policies and investments tailored directly to the sector, such as those related to knowledge and skill-building. Vocational training models that combine "on-the-job"-training at the workshops of manufacturers with "in-classroom"-teaching in training centers are a particularly proven and promising solution (Daum & Kirui, 2021; Signé, 2018). This approach is pursued in all four case study countries, however, so far, while informal on-the-job training is already widespread, it is mostly not combined with training at vocational centers. The results also suggest that knowledge and skills-building efforts at existing institutions for vocational training and higher education are at times outdated, and often too theoretical, suggesting a need for refreshers courses for teachers and updated curricula, including paying more attention to some of the latest technological developments such those related to renewable energy and better integration of theory and practices (FAO & AUC, 2018; Kirui & Kozicka, 2018).

There is also a need for training for already existing manufacturers. This could take innovative formats where trainers meet at the workshop of manufacturers to discuss the scope for improvements or where manufacturers bring their latest products to the training compounds, among others (FAO & AUC, 2018; Houmy et al., 2013). Valuable lessons can also emanate from the exchange with other manufacturers within their countries, from other African countries, and other regions such as Asia (Gulati & Das, 2020). Next to engineering knowledge and skills, both today's and future manufacturers need to be better equipped with entrepreneurial knowledge and skills (Dihn et al., 2012; FAO & AUC, 2018; Signé, 2018). But the success of manufacturers does not only hinge on their knowledge and skills. Given the large capital constraints, a better investment climate and long-term financing options can help local manufacturers to invest in production equipment to improve product quality and enhance productivity. Given the limited access to land, policies related to industrial land (e.g. industrial parks) could help them to grow and use synergies.

While private research and development play a central role in manufacturing, there is still a need for long-term public research related to the design of new machinery and local modification and adaptation of machinery (Biggs & Justice, 2021; Binswanger & Donovan,

1987; Bhattarai et al., 2020; Cramb & Thepent, 2020; FAO & AUC, 2018). A whole new area for research and development relates to the use of renewable energy as a power source. Making sure that African manufacturing sectors are powered and that African agricultural value chains are mechanized using renewable energy solutions is key for climate change mitigation and can help farmers and other value chain actors to become independent from the patchy and costly electricity supply (see also Bouchene et al, 2021). The potential for using renewable energy to power mechanization is high, particularly related to post-harvest handling and food processing (IFC, 2019). It is encouraging that a small but significant share of the local manufacturers has experimented, or already offer solutions, in this regard. Importantly, when investing in research and development efforts, the linkages between public research and development and local manufacturers should not be forgotten, to ensure that the developed engineering solutions do not end up on the shelf (see also FAO & AUC, 2018; Houmy et al., 2013). Such linkages should not only be one-way; public research and development organizations can learn as much from local manufacturers as vice-versa.

The results strongly suggest that the success of local manufacturers in Africa is also shaped by more "invisible" aspects related to the regulatory framework such as trade regulations, testing, certification, licensing, standards, and the costs of doing business, confirming evidence from other world regions (see also Bhattarai et al., 2020; Binswanger & Donovan, 1987). While trade barriers within Africa generally have been reduced over the last few years, trade policies affect the availability, quality, and costs of raw materials and production equipment in the four case study countries (see also Signé, 2018). In the four case study countries, as well as other African countries, most agricultural machinery is exempted from import duties, however, the raw materials needed by local manufacturers are charged with – sometimes high – duties (see Diao et al., 2020; FAO & AUC, 2018) 4. The empirical data suggest that few manufacturers sell to customers from outside their regions (17%) or other countries (2%), even if they have similar agroecological conditions, which can be attributed to infrastructure problems, transaction costs, and unfavorable trade policies and practices, among other reasons. Investments and policies to support regional trade and integration could help to change this. Regional associations that bring together manufacturers in neighboring countries might be useful.

Testing and certification are other important topics. Across the four countries, only 19% of the manufacturers reported that their machinery is subject to some form of third-party testing and certification. Informal mechanisms related to reputation can only partly counterbalance

[4] However, it is also important to point out that importers also face constraint due to tedious and slow import procedures and "unofficial" duties can also affect machinery imports (Daum & Birner, 2017; Diao et al., 2020).

this lack. In the absence of impartial testing and certification, it is difficult for customers to choose reliable machinery, and they may resort to suboptimal mental aids such as choosing international over domestic production (see also Daum & Birner, 2017; FAO & AUC, 2018; Houmy et al., 2013). Testing and certification can create upward pressure on manufacturers to raise the quality of their products. In the absence of testing and certification, quality can vary widely, and the so-called “lemon-market problem” can lead to a downward spiral of quality (or even fraud) since customers consider only prices for decision-making (Daum & Birner, 2017). To reduce the uncertainty and risks for customers, machinery testing has emerged across the world, either through public-, private-, or third-sector mechanisms (Daum et al., 2018). When making tests easily available for customers, including in the form of certificates, allows them to make better decisions (see also FAO & AUC, 2018). FAO & AUC (2018) suggest that given the significant costs of public testing centers, countries could set up regional testing centers, following the example of the “Asian and Pacific Network for Testing of Agricultural Machinery” (ANTAM). These bodies can also play a role in much-needed standard setting. Lastly, efforts are needed to reduce the costs of doing business, thereby reducing the transaction costs and risks between manufacturers and suppliers, and customers, among others.

In summary, this paper suggests great potential for local agricultural manufacturing to contribute to overall economic development in Sub-Saharan Africa. Markets for local machinery have emerged in all of the African case studies countries, despite a wide range of challenges. These markets are dominated by small but dedicated local machinery manufacturers, many of whom are guided by the vision of bringing innovative engineering solutions to help transform agriculture. Ensuring a more supportive, enabling environment can help these local manufacturers to fulfill this vision, and harness their comparative advantages, vis-à-vis global manufacturers. The return of local manufacturing to the development agenda of African policymakers is a promising sign. But it must be ensured that policies and investments do not focus on a few, politically attractive flagship projects, but are rather designed to maximize the long-term success of the sector. With the right policies and investments creating an enabling environment, local manufacturers can produce the machinery to make “Made in Africa” the first choice of farmers and agro-processors.

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