# Framing manufacturing processes resource requirements in underdeveloped countries: a study on industrial investments in Africa.

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**Abstract**: Africa is becoming an attractive destination for private investors, though the opportunities it offers are not being fully exploited. There is widespread evidence that industrial settlements play an important role in a country's economic development, however, adopted approaches and strategies seem not to be adequately structured to meet the challenges. For this reason, manufacturing companies need recommendation to penetrate one of the fastest growing consumer markets in the world, to easier settle production sites and consequently achieve greater investments effectiveness. Conversely to recent progresses, significant obstacles owing to political instabilities, conflicts, poor infrastructures and geographical diversities persist. Under such circumstances, a crucial driver to success is the ability to lead the industrialization according to process requirements and impacts within a certain underdeveloped territory. Notwithstanding obvious need, to date no framework based on the strength of these features seems to exist. Consequently, it is necessary to design guidelines on developing countries manufacturing processes opportunities, providing companies an extensive and responsible vision that will positively contribute to both industrial settlements competitiveness and Africa development. Recent research on investment dynamics and industrial development in Africa have highlighted the need to identify main input and output categories that characterize all industries in a developing country. More precisely, this classification will assist private investment in the choice of the type of industry given the production resources, notably factory utilities and raw materials availability. This objective is achieved through in-depth analysis of different industrial processes, identifying and describing specific process requirements and results, per industry type. Afterwards, the identified categories compose a framework which has been applied to two different industries. In particular, the result shows the framework applicability and its potential to understand production resources availability and manufacturing development opportunities.

**Keywords**: Underdeveloped Countries; Industrial Processes; Production Resources; Industrial Development.

## 1. Introduction

Industrialization has a key role for the country's development, and it can create both structural change and socio-economic development. Moving from an agrarian economy to an industrial one is essential for creating wealth in an underdeveloped country (UNIDO, 2016). Hence, industrialization represents the main modality for reducing poverty and unemployment (Signé & Johnson, 2018). Africa includes the fastest growing developing countries and the great contribution of industrialization to growth is amply demonstrated. Although Africa is growing strongly, it differs not only country by country but also sector by sector (McKinsey, 2010), so it is important to analyse and exploit industries characteristics and opportunities. While for investments in developed countries it is necessary to consider mainly complex dimensions, the drivers supporting industrial settlement in developing countries are also related to basic factors, such as the presence of clean water, electricity, viable roads, personal safety or political stability. Furthermore, low levels of education and cultural diversity make specific skills availability limited. Consequently, to set up production sites as efficiently as possible, there is a need to have an all-encompassing vision of the industry requirements and territory characteristics. Indeed, a non-optimized locations selection can adversely affect a plant's performance in terms of productivity, production costs and logistics. To date, companies do not have a resource and impact-based framework to be guided in setting up new production facilities in African underdeveloped countries.

This paper seeks to provide a set of categories that a company should consider evaluating its settlement capabilities in an underdeveloped country. Above all, there is the need to identify and group the industries required resources, distinguishing them by their ability to create added value both at an economic and social level. Specifically, the categories need to be organized into resources as inputs and impacts as outputs. The main complexity is carrying out an in-depth analysis of several industrial processes, identifying as many categories as

possible, making them general enough to be suitable by any kind of industry. Notably, there is a real opportunity for companies to create jobs, promote inclusive economic transformation and support productivity growth through automation, quality management, process improvement and training (Dinh, et al., 2012). Africa's competitive advantage in manufacturing is driven by its demographic composition and resource abundance (Signé & Johnson, 2018). Such reliance on resources must necessarily consider that not all Africa locations have the same resources capacity and not all industries require the same resources. Consequently, it makes sense to guide companies in setting up production sites by considering the resources that a certain type of industry requires. More precisely, this classification aims to assist private investment in the choice of the type of industry and the location given the production resources, notably factory utilities and raw materials availability, and impacts. In particular, the question is whether it is possible to build a framework that helps companies to understand how to position new production facilities in underdeveloped countries through requirements and impacts classifications.

In this paper, after a literature review, the framework is defined by describing how the input and output categories are collected and categorized. Afterwards, two cases of application on textile and food industries are provided. The results show the framework applicability and its potential to understand production resources availability and manufacturing development opportunities.

## 2. Literature review

In order to provide a clearer view of the state of the art, previous research is divided according to the themes dealt with. After highlighting the articles that confirm the opportunities of industrialization investment in Africa, the various initiatives that support this phenomenon are analysed. Then, the theses in support of the importance of resources and impacts that characterize the productive settlements are treated. The relevant existing frameworks are contemporary analysed, highlighting their advantages and limitations. In order to learn from the failures and successes of others, the role of China in Africa is studied, and the limitations of the implemented approach are investigated.

Several articles (Opoku & Yan, 2019) (Signé & Johnson, 2018) highlight the potential of productive settlements in Africa. According to the African Development Bank-Group, industrialization is one of the five priorities that most rapidly lead to create added value for both companies and population (African Development Bank-Group, 2017). There are several initiatives, both private and public, that organizations are carrying out to contribute Africa's industrialization development. While state-owned companies' investment projects in Africa focus on the infrastructure, energy, construction and resource sectors, private investments invest in less capital-intensive sectors such as manufacturing, trade and logistics. Africa Union, in collaboration with the OECD Development Centre, promotes initiatives to drive Africa development strategies (AUC/OECD, 2018). These include private investment simplification for business productivity benefit, technology and know-how, such as urban infrastructure, services and education. UNIDO is taking forward Africa's industrialization agenda by requiring the creation of a favourable environment that strengthens internal capacity in infrastructure, human capital, financial systems, research and development, technology and governance (UNIDO, 2018). Furthermore, the "Policy framework for investment" (OECD, 2015 ) proposes a guide of twelve policies to make the country more investment friendly, encouraging infrastructure, access to resources and education development. The Trade and industry Department of South Africa provided a National Industrial Policy Framework (DTI, 2007) and an Industrial Policy Plan (DTI, 2019), both aiming to reorient the South Africa's industrial policy. The framework identifies four main sets of policies need to be implemented for successful industrialization, i.e. stable regulatory environment, education, traditional infrastructure and technology innovation. In fact, industrialization planning needs to be related to matters like macroeconomic stability, required skills, sufficient and reliable logistics system, location and provision of housing, electricity, telecommunications and water supply. It is important to stress out that this is a Policy Framework, aiming to set out government's approach to the industrial development of the South African economy. However, the factors to be considered for industrial settlement are very heterogeneous in the different territories of the African continent. Indeed, significant differences across countries regarding specific resources opportunities exist (Fessehaie & Rustomjee, 2018). This differences recognition is mostly limited to general information and is not linked to a detailed and quantitative analysis of industrial process and specific territory real conditions. The main challenge is to find information on the availability and quality of local suppliers, i.e. information about the necessary inputs presence in the territory where the new production site will be located (ITC, 2018). In this research, ITC provided information about the local capacity and the quality of business ecosystems. The limitations of this report are that it focuses only on 5 countries Gambia, Ghana, Kenya, Morocco and Zambia and on how to improve partnerships with local suppliers in these specific locations. Building a report to list the present companies in the territory is useful but does not provide decision keys that a company should consider evaluating its settlement capabilities in an underdeveloped country. In that way, it provides static information that may change from one period to another. Moreover, this publication examines only the non-extractive sectors, as they are more relevant for Chinese private investors and for the sustainable development of local industries.

In fact, China plays a fundamental role in the African economy, exploiting natural resources and positioning itself locally (Brautigam, et al., 2017). However, Chinese investment in Africa is not large enough (Abebe, et al., 2019) so other countries can exploit its potential. Several studies (Ado & Su, 2016) question on what basis the Chinese countries invest in Africa. Chinese FDI in Africa is mainly driven by two factors: natural resource endowment and market opportunities (Amighini , et al., 2017). Despite the economic engagement between China

and Africa, no structural transformation occurred (Geda, et al., 2018). Sustainable economic growth in Africa continues to be constrained by the weakness of the manufacturing sector (Lu & Liu, 2018), and African economies require urgent structural changes from an industrial point of view (Qobo & Pere, 2018).

Indeed, there are several limitations to the approach taken so far for investment in Africa. The main problem lies in the high dependence on imported technologies that are not suitable for African resource allocations (Atta-Ankomah, 2016). Industrialization is constrained by a set of limitations, among the ability of companies to deliver goods, the quality of infrastructures, human capital education and training , political stability and finance access (ZEPARU, 2014) (World Bank, 2014) (Davies, et al., 2012). An additional problem is the lack of visibility and credibility of the enterprises operating in Africa (UNDP, 2013). Developing a framework that companies can use to locate their production sites is an opportunity to give investors and customers comfort around mission protection and social value creation. According to Dinh, companies identify inputs, including availability, quality and cost, as one of the primary obstacles to productive development (Dinh, et al., 2012). Despite resources importance understanding, Dinh's research focuses mainly on the input costs effects on competitiveness, giving strategic suggestions. In addition, companies must learn from the failures and successes of others to succeed on the continent (McKinsey&Company, 2015). Successful industrialization is driven by a combination of factors, including the country's factor endowments (UNIDO, 2017). The most successful companies entering Africa are those who targeted locations with the needed characteristics to make their settlement successful.

It is evident the lack of guidelines to allow companies to establish production sites in Africa, based on the necessary resources and the ability to generate an economic, social and environmental impact. Identifying industries input and output macro-categories is a science and business need.

## 3. Framework definition

The framework was designed through in-depth analysis of different industrial processes. This analysis focalized on identify the input resources and the impacts of each production process. First, the industrial types to be studied were identified. Then the related processes were studied to extrapolate the input and output categories. Finally, a method of measuring the relevance of these categories was identified.

### 3.1 Categories identification methodology

The categories extraction process has been achieved through three main phases. The first one corresponded to the extraction of main categories from existing frameworks and guidelines; the second one corresponded to the selection of the industries to be analysed, the third one corresponded to their processes analysis in order to corroborate and supplement the categories. Hence, the major issues that have been highlighted in the literature review have been collected, e.g. the lack of policy coherence, the performance of the logistics system, inappropriate skill levels, the concentration of ownership and control, high private sector input costs, the water supply availability due to the recurrent interruption, logistics and telecommunications constraints, electricity supply unpredictability, inappropriate location and provision of housing. These key challenges were then renamed, classified and integrated based on a deep industrial processes study (Colombo, 2012). Before proceeding with the industrial processes study, it has been necessary to select a set of industries to analyse, basing on two main aspects. First, the set needed to be as varied as possible so that requirements and impacts categories identification can be generalised towards other industrial groups. Secondly, it needed to fit with the characteristics of African countries. Particularly, the low technology industries (UNIDO, 2010) are most appropriate for a developing country, that still has major limitations in terms of infrastructure, technology and skills. In fact, the main investment opportunities are currently concentrated in sectors that are labour intensive or require the use of locally sourced raw materials.

UNIDO listed the following low technology industries:

(i) Food products; (ii) Beverages; (iii) Tobacco products; (iv) Textiles; (v) Wearing apparel; (vi) Leather and related products; (vii) Wood and products of wood and cork; (viii) Paper and paper products; (ix) Printing and reproduction of recorded media; (x) Coke and refined petroleum products; (xi) Fabricated metal products except weapons and ammunition; (xii) Furniture.

Subsequently, for each of these 12 industries the production process was deeply studied (Colombo, 2012) to integrate the categories that have been highlighted in the literature. The categories have been abstracted and organized to set up a generalized, but deep framework. To give an example of category abstraction, it is to be noted that the major raw materials for the textile and apparel industry include cotton, jute, silk, wool and man-made fibre. Hence, these inputs have been grouped in a cleaner and comprehensive "Textile fibres" category. Another example can be provided considering that the food industry uses salt, smoke and acids, that belong to a more general category of "Natural Chemicals". The following paragraphs show the identified input and output categories.

### 3.2 Input categories

The input categories are divided into three levels, consisting of 4 macro-categories, 10 categories and 62 input details. Figure 1 shows the complete framework of the identified inputs. The identified macro-categories are:

(i) Resources; (ii) Capital; (iii) Infrastructure; (iv) Management requirements.

In the macro-category "Resources" there are natural resources, i.e. those whose presence in the territory is necessary, and raw materials, which can also be imported. "Capital" macro-category is divided into economic, i.e. the cost of investment and maintenance, human, i.e. the need for workforce and skills, and plant. Under "Infrastructure" macro-category, transport networks, i.e. roads, railways, airlines and maritime lines, and local installations, i.e.

electricity distribution lines, aqueducts, sewerage systems or institutional, security and healthcare institutions are distinguished. It is important to point out that the difference between "capital"/"plant" and "local plant" derives from the fact that the first one can be directly installed by investors, the second one should exist in the territorial area. "Management requirements" category includes the hygiene requirements, such as air and water purity, the control of atmospheres, emissions, temperature and process, the investigation need, such as geophysical and geochemical surveys.

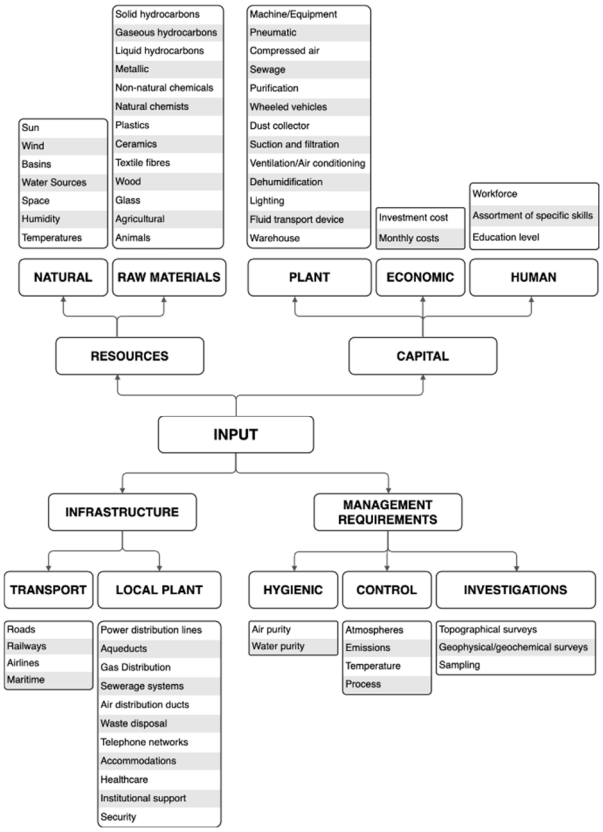


**Figure 1: Input categories**

### 3.3 Output categories

The output categories are divided into three levels too, consisting of 3 macro-categories, 6 categories and 29 output details. Details of the output categories are shown in Figure 2. The macro-categories are classified based on the generated impact, which may be:

(i) Economic; (ii) Social; (iii) Environmental.

The "Economic impact" is distinguished between that on the country, such as an increase in the number of jobs and an increase of the country's GDP, and that on the industries which are already operating in the territory. In fact, the settlement of a certain industrial typology can induce the economic activity increasing of another one. The "Social impact" is related both to skills, i.e. how much industry increases the level of competencies and specialization of workers, and to quality of life, which can be improved in terms of public services. The "Environmental impact" can result both from pollutions, e.g. noise or air pollution, and wastes, e.g. solid, powdered, hazardous or non-hazardous.

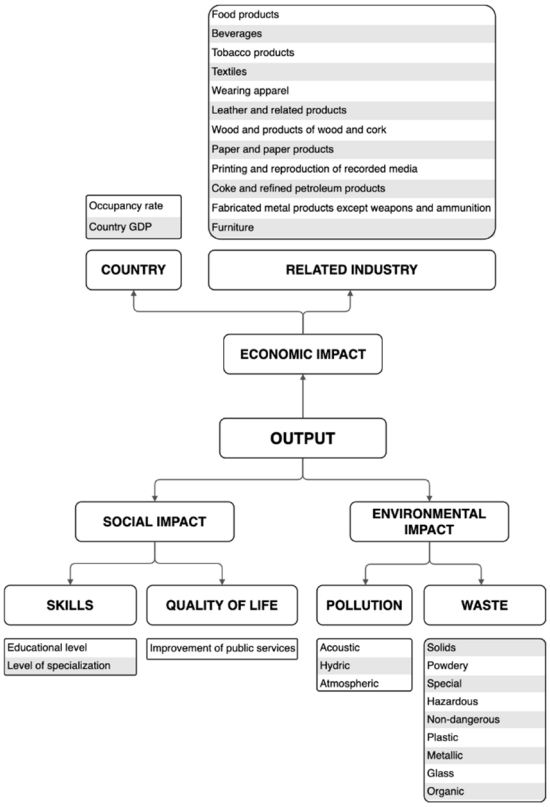


**Figure 2: Output categories**

### 3.4 Categories measurement

The measurement objective is to understand how relevant each category is for the company that wants to settle its production site in Africa. While for qualitative categories the complexity level can easily be described as level of importance, criticality or need, for quantitative categories the manufacturing industries complexity measurement methodologies have been analysed. ElMaraghy et al. collected existing complexity measures, e.g. project size, engineering problem, entropy, relationships between system components, product combinations number, variety and quantity (ElMaraghy, et al., 2005). Among them, volume and variety are the most commonly measuring instruments used and the most suitable measurement systems for the identified categories. In fact, the Volume-Variety Matrix (Hayes & Wheelwright, 1979) is a well-known tool to link market demands with operations requirements and easily decide management strategies to be adopted. In line with the literature, volume and variety measurements were selected to estimate categories complexity. The identified categories have a wide variety of units of measurement; hence, all categories must be scaled to a standard measurement system. In addition, complexity is a company peculiar and latent value based on how restrictive a certain category is for its specific production process. Likert-type scales are useful to measure latent aspects and to set the categories at the same unit of measurement. The Likert scale was introduced by Likert (1932) and consists of five levels: minimum, minor, moderate, major and most, with scale scores of 1, 2, 3, 4 and 5 respectively. The scale has been revised by adding one more state, the level "0" indicating the absence of a certain category. In fact, the framework includes several

categories that aim to cover any industrial typology, but not all industries have all the identified requirements. For example, for the food industry, "Textile fibres" raw materials category assumes level "0" as not needed. In addition, the level from 0 to 5 can express both quantitative aspects, as range of quantity or variety, and qualitative aspects, as level of importance. Finally, a complexity scale from 0 to 5 allows to have a sampling that is both precise and easy to compile for companies. In fact, each company that uses the framework defines its own categories complexity values as customizations based on how strict that category is in that specific production process.

## 4. Application to Textile & Food Production

This paragraph aims to show the applicability of the framework and its potential. The application of the framework consists in the definition of the categories complexity levels. More precisely, the company that uses the framework indicates a value from 0 to 5 for each category, providing its process relevance evaluation. Particularly, several discussions with representatives of two companies, one in the food sector and one in the textile sector, have been carried out. As a result of these discussions, the levels of the identified categories have been defined. It is worth pointing out that companies within the same sector may have different characteristics, so the inserted thresholds are demonstrative values and not indicative of all textile and food industries. Figure 3 shows the identified categories values of the two industries processes. To provide more details on categories values, only certain categories with different complexity level between textiles and food have been reported. The bar level height increases with increasing complexity.

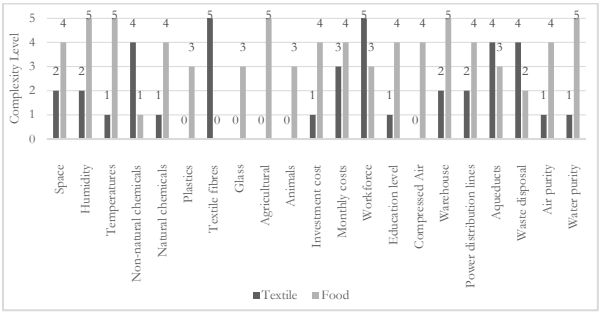


**Figure 3: Food and textile input categories comparison**

This application provided a generic comprehension about the different resources needs and the critical issues to be faced in setting up both production site. Particularly, it immediately emerged that, unlike the textile industry, the food industry should be in a territory where temperature and humidity are within certain ranges. In fact, in the food industry, the measurement of physical quantities such as temperature and relative humidity is essential, for goods acceptance control, storage, cooking process, but also for the transport of sensitive goods. In the food industry, processing combines basic food ingredients such as sugar, honey, cereals, dairy products, eggs, vegetables, fruit, animals, coffee, tea, cocoa and spices, so agricultural products and animals are used. Conversely, textile fibres are only used by the textile industry. The textile industry is labour intensive and requires low level of education. Contrarily, the food industry is becoming progressively more automated, requiring less workers but more specific skills. The food sector differs from the other industrial sector because of the processing processes multiplicity and the relative shares of energy used to produce them. Among the food industry utilities there are auxiliary equipment that provide the necessary resources for the operation and maintenance of a food processing plant, such as pneumatic, compressed air, purification and dehumidification. In addition, the warehouse of the food industry is much more critical than that of the textile industry, both in terms of space and in terms of temperature and humidity characteristics. In fact, in the food industry, the type of warehouse and storage life are related to the stored food type, storage life and storage requirements. Both industries need a high volume of water, but the textile industry does not require special attention to air and water purity, which is essential in the food industry. In fact, the food industry demands impeccable quality water in compliance with the highest standards of hygiene, health and safety.

Most output categories derive directly from the related input category compilation. For example, the occupancy rate and the social impact on education level are respectively function of the workforce category and the education level. Obviously, the waste material varies according to the employed resources. The textile industry uses a large amount of non-natural chemicals as dyestuffs; conversely the food industry only uses sorbic acid, sulphur dioxide and benzoic acid to preserve the material. Hence, the textile industry is much more water polluting than the food industry, given the large utilization of chemical elements. In the food industry, packaging such as boxes, jars, bottles or cans are necessary. As a result, glass and plastic are types of waste that have environmental impacts.

## 5. Discussion

The framework application clearly highlighted the potential of the proposal. In fact, the companies that used the framework obtained the awareness and the overview of the most critical aspects to consider when assessing their capability to settle in an underdeveloped country. Reasonably, there are some critical resources that are difficult to find in some African regions, while other resources may be easier to obtain. When the characteristics of the territories will be also mapped, the most suitable area can be chosen for each industry. Considering the low levels of education and cultural diversity, this first application showed that it might be easier to set up a textile rather than a food production site in Africa. In fact, underdeveloped countries have a poor education system and the textile industry does not require specific skills and education. Contrarily, the food industry is more technologically advanced and requires more specific skills. For example, sub-Saharan Africa has the highest rates of no education. Both industries require a high quantity of water, and this resource is not always guaranteed in Africa. In addition, food industry has stringent water purity requirements, that are not easily accessible in underdeveloped areas such as Africa. For example, in Angola more than half of the population does not have access to a clean water source. Another unreliable resource in an underdeveloped country

like Africa is electricity. For example, North Africa has good access to electricity, but more than half sub-Saharan population does not have access. (Economist, 2019). The food industry is more technology advanced, therefore requires more to be powered. In addition, the textile industry needs a territory with not too high humidity and temperature. Considering the outputs, the occupancy rate is the most valuable impact for an underdeveloped country that needs to create jobs. Again, the textile industry which is labour intensive could be the most suitable. Hence, the paper's provided guidelines are related to the identification and classification of the categories that a company should consider evaluating its settlement capabilities in an underdeveloped country. Clearly, more detailed guidelines will be customizable for each company using the framework and in association with the study of African territories characteristics.

## 6. Conclusions and further developments

This research aimed to build a framework to guide the production sites settlement in underdeveloped countries. Particularly, the literature showed that it is relevant to consider requirements and impacts to establish production sites and a proposal that considers these aspects is missing. Consequently, the construction of the framework is useful in scientific and business field. All the previous research focused on political and strategic aspects to stimulate private investment. Furthermore, existing frameworks provided limited aspects that did not consider the production processes requirements. Instead, this framework focused on the identification of inputs and outputs macro-categories to analyse needs and sustainability of the industrial type. The framework was implemented through in-depth analysis of different industrial processes. To extrapolate the input and output categories, the industrial types to be studied were identified. Nevertheless, any type of industry can use the framework. Finally, volume and variety measurements were selected to indicate identified categories complexity. Two cases of application were then reported. Indeed, following discussions with representatives of a textile industry and a food industry, category levels were defined. It is important to specify that the identified levels are not indicative of all companies in the food and textile sector but are customized levels of the two specific companies. In fact, each company that uses the framework, must establish the levels of complexity based on how strict that category is for its specific production process. More precisely, within the same sector companies may have different characteristics, therefore the framework aim is to allow the specific company to enter their own categories complexity values through personal assumptions. This application intended to show the applicability of the framework and the two industries criticalities. Subsequently, the framework could be compiled by other industrial typologies to provide a possible picture of the other low-tech industries. To endorse the usefulness of this framework, practitioners should consider the construction of a complementary framework on the African countries characteristics, through which affinity relations between country and industry can be provided. Moreover, the developed framework should be supported by another framework that highlights the needed workers competences. Given the cultural diversity in developing country, this framework should determine causes, effects and relationships between new production site establishment and required skills. In fact, after promoting low-tech and labour-intensive production, more complex jobs with higher skills and high technology can be started (Dinh, et al., 2012). In conclusion, this may represent a first step in a broader research stream aimed at supporting companies expanding their production facilities in Africa, developing a valid method that highlights which countries are best suited for their industry sector.

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