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# Local content requirements in auction schemes for renewable energy: Enabler of local industrial development in developing countries?

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# LOCAL CONTENT REQUIREMENTS IN AUCTION SCHEMES FOR RENEWABLE ENERGY:

# ENABLER OF LOCAL INDUSTRIAL DEVELOPMENT IN DEVELOPING COUNTRIES?

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# ABSTRACT

Given the increasing cost-competiveness of renewable energy (RE) technologies, competitive auction schemes have increasingly been adopted in recent years across various developed and developing countries. Local content requirements (LCRs) are frequently used as part of RE auction schemes to promote local industrial development. In this paper, we present a review of the literature on the effectiveness of LCRs in fostering local industrial development across various developing countries, focusing on South Africa, Brazil, India and China. Specifically, the paper analyses the effectiveness of LCRs in promoting the establishment of local manufacturing facilities of onshore wind turbine and solar PV components in these countries. Further, the paper provides a review of the main determining factors stressed in the literature to account for variation in the effectiveness of LCRs. We find that the literature generally ascribes importance to the role of LCRs in stimulating local component production in developing countries. However, previous research on the effectiveness of LCRs in establishing local component manufacturing differs across the technologies and the countries analysed. The variation in the effectiveness of LCR can be explained by a framework that combines the following four determining factors: (i) market size and stability; (ii) policy design and coherence; (iii) the restrictiveness of the LCRs; and (iv) the domestic industrial base. The paper highlights a lack of systematic approaches and rigor in existing research, thus proposing the development of a common framework and a set of indicators to assess the efficiency of LCRs.

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# 1. INTRODUCTION

Industrial policy mechanisms have long been used as a means of facilitating local industrial development in developing countries. One way of attempting to ensure this has been the policy requirement that lead firms incorporate various types of local content requirements (LCRs) into their supply chains in order to develop domestic production capabilities (Lall, 2013). With the spread of renewable energy (RE) in the developing world, LCRs have become an integral component of various wind and solar energy programs in order to localise suppliers. However, this raises the question of the efficacy of such LCR schemes if they are not integrally linked to broader industrial policy regimes. LCRs can reinforce industrial policy, but they might not be effectively sustained if the overall industrial policy regime is not adequate (Lewis and Wiser, 2007).

Globally three major RE schemes have been utilised by various governments: feed-in tariffs, quota allocation and, more recently, competitive auctions. The use of competitive auction-based schemes (also referred to as 'competitive tenders') to support the development and diffusion of large-scale RE technologies has gradually superseded previously used instruments, such as feed-in tariffs (or premiums) and quotas (or renewable portfolio standards). Indeed, IRENA (2017) found that the number of countries that have adopted auction schemes for RE increased from six in 2005 to at least 67 by mid-2016, a trend that has continued subsequently. A main reason for the increasing use of RE auction schemes as the preferred policy instrument is the increasing cost-effectiveness of various RE technologies, such as wind and solar photovoltaic (PV). Price and performance improvements in the core components, such as solar panels and wind turbines, have increasingly made such technologies competitive compared to conventional sources of electricity generation based on coal, natural gas, oil and hydropower. The advantages of RE auction schemes compared to other supportive policies, including direct negotiation, lies in their potential to achieve lower prices by stimulating competition and in their flexibility, transparency and ability to ensure certainty in price and quantity (IRENA, 2015; Eberhard et al., 2016).

RE auction schemes typically comprise specific requirements aimed at contributing to achieving various political and socio-economic development objectives, including employment generation, attracting foreign direct investment, ensuring local ownership and upgrading the local industrial base. Examples include requirements for local ownership, community development and local content (Baker and Wlokas, 2015; Eberhard and Kåberger, 2016). The bids submitted by investors and project developers will therefore be evaluated on the basis of such requirements in order to win contracts for developing projects as part of the RE auction schemes. LCRs are typically used as the main instrument in RE auction schemes in nurturing and stimulating local industrial development by stipulating the use of locally produced content. It is therefore of interest to explore the effectiveness of LCRs specifically in relation to auction schemes given their current popularity as the preferred policy instrument for supporting the diffusion of large-scale RE technologies.

The present paper provides a review of the literature on the use of LCRs in RE auction schemes adopted across various developing countries with a focus specifically on South Africa, Brazil, India and China in order to present an overview of the state of the art within this field of research. The paper engages critically with previous studies in the field by examining and discussing their empirical findings on the effectiveness of LCRs on local industrial development. We focus on onshore wind power and solar PV, as these are rapidly developing RE technologies in terms of market development and installed capacities and have typically been a major element of RE auction schemes adopted globally. Accordingly, these technologies have been covered most extensively in the literature with specific reference to the countries of interest in this paper.

The paper is guided by the following two overarching research questions:

- What are the main impacts of LCRs on local industrial development identified in the literature?
- What are the key explanations provided in the literature to account for variation in the effectiveness of LCRs across countries and technologies?

The remainder of the paper is structured as follows. Section 2 describes the research methods used to prepare the literature review. Section 3 presents the conceptual framework that guides the paper. Sections 4 and 5 present the main empirical findings of the paper, focusing first on the effectiveness of LCRs and secondly on the determinant factors for the effectiveness of LCRs across the countries and RE technologies analysed. In Section 6, we present a discussion of the empirical findings, while the main conclusions are provided in Section 7.

# 2. RESEARCH METHODOLOGY

The paper is based on a review of the literature on the use of LCRs to promote local industrial development as part of RE auction schemes adopted across various developing countries. As already mentioned, we focus on the countries and technologies that have been covered most extensively in the literature: South Africa (wind and solar), Brazil (wind and solar), India (solar) and China (wind). Given the focus on LCRs as part of RE auction schemes, we do not consider documents examining the effectiveness of LCRs to be part of other types of support policy, such as feed-in tariffs. The review has been conducted as comprehensive and systematically as possible following methodological guidance from the literature (Tranfield et al., 2003). Accordingly, in order to identify relevant sources in the peer-reviewed literature, we made use of Scopus and the Web of Science databases using various combinations of search strings that incorporate key notions such as "local content", "requirement", "domestic", "manufacturing", "assembly", "renewable", "energy", "wind", "solar", "auction", "South Africa" and "China". The review was therefore limited to documents written in English. After a number of iterations using such combinations, the list of papers did not go beyond nineteen academic papers published in journals indexed in Scopus and Web of Science. In addition, we made use of Google Scholar, Internet Search and reference snowballing technique (Wohlin, 2014) in order to identify 29 reports, characterized as "grey literature", including government reports, working papers and publications prepared by various consultancy and donor organisations. All these 48 papers and reports were hosted in the reference management software Mendeley, which enables searches for concepts and keywords of interest across the set of documents. Excerpts of relevance were extracted from the documents and quoted to support the narrative presented in the paper. All the documentary sources identified were published between 2007 and 2018.

# 3. CONCEPTUAL FRAMEWORK

The purpose of this framework is to assess the effectiveness of LCRs on local industrial development and the explanatory determinants for their effectiveness.

## 3.1. EFFECTIVENESS OF LCRs

In RE auction schemes, LCRs are typically defined as the percentage of the total project cost sourced locally through both equipment and services, including locally produced components, civil engineering work and consultancy fees (IRENA, 2013). A key question is how studies go about measuring the effectiveness of LCRs. Across the literature, measurement of LCRs includes a variety of quantitative metrics such as local labour market (net) impacts, including welfare, wages and employment effects (e.g. number of jobs created) (Tordo et al., 2003). Local content is also measured as the number of new local manufacturing firms established after LCR implementation, the expansion of the number of projects or sales in existing firms, or the number of activities subcontracted to existing local producers (measured, for example, by the number of individual contracts awarded to local suppliers) (Tordo et al., 2003). Such measures of local impacts of LCRs often overlap. For example, the number and types of jobs created could also be an indirect measure of the effects on local manufacturing. There is also the question of timing, which relates not only to the point in time at which the studies are undertaken relative to the implementation of LCRs, but also whether studies consider the short-, medium- or long-term effects.

There are obvious caveats to this approach to measuring impacts in terms of local production. First, it may be difficult to distinguish clearly whether new factories were created as a direct result of the LCRs or whether other factors played a role. Second, the establishment of new local factories as a consequence of LCRs may cause existing ones to go out of business, and such net effects may be hard to disentangle. Third, in some

cases, it may be unclear whether LCRs result in the establishment of new manufacturing plants or whether this is a question of the expansion of sales in existing facilities and/or related to the diversification of existing businesses in related industries.

Notwithstanding these caveats, we focus on the effects of LCR that are reported by various studies in terms of the number of new enterprises created subsequent to the implementation of LCRs, i.e. new investments in productive assets locally. From a developmental perspective, this focus on the creation of local manufacturing facilities is pertinent as it typically involves long-term employment compared, for example, to short-term construction jobs (Cameron and Zwaan, 2015). Furthermore, local manufacturing is generally considered a key feature of the structural transformation underlying industrialisation in developing countries (Newman et al., 2017; Stiglitz et al., 2017; Signé 2018). Industrial policy, including the use of LCRs, may play a crucial role in promoting such industrialisation, pointing to the importance of the state as a key enabler in fostering local production as a starting point for further upgrading toward higher value-added activities in value chains (Horner, 2017).

## 3.2. DETERMINANTS OF THE EFFECTIVENESS OF LCRs

Traditionally, LCRs are aimed at supporting infant industrial development by providing domestic industries with temporary protection from the competitive pressures of normal market conditions (Veloso, 2001). Accordingly, LCRs allow domestic firms to develop in order to become internationally competitive before being subject to competition from foreign companies. LCRs have been widely adopted across various sectors and countries, including the oil and gas sector, extractive industries, consumer manufacturing industries and the automotive sector (Tordo et al., 2013). Most recently, the role of the state has received renewed attention in an emerging literature on green industrial policy, which often stresses the use of LCRs as a key instrument in fostering local industrial development in green technologies (Altenburg and Assmann, 2017). In this paper, we draw specifically on the literature on the use of LCRs in RE auction schemes, which, as shown in Ettmayr and Lloyd (2017), has converged toward a common set of key determinants to assess the efficacy of LCRs in promoting local industrial development. Accordingly, we focus on the following four main determinants put forward by Veloso (2001), Kuntze and Moerenhout (2013) and Johnson (2016): (i) market size and stability; (ii) policy design and coherence; (iii) the restrictiveness of the LCRs; and (iv) the domestic industrial base (see Table 1). These will be elaborated in the following.

**TABLE 1. MAIN DETERMINING FACTORS FOR THE EFFECTIVENESS OF LCRs IN RE AUCTION SCHEMES.**

| Factors | Characteristics |
|---|---|
| **Market size and stability** | • The level of domestic market demand in terms of auctioned volumes<br>• The degree of predictability and long-term stability of the demand, for example, through target setting and political signals |
| **Policy design and coherence** | • The clarity and transparency of the rules and regulations pertaining to the LCRs, including definition and implementation procedures<br>• The extent to which LCRs are aligned with and accompanied by complementary industrial policies supporting local manufacturing in the targeted sectors |
| **Restrictiveness** | • The level or percentage of locally produced content required under the LCRs |
| **Industrial base** | • The level of technological capabilities in the local supply base, including technical skills, specialization and the production capacity of domestic firms |

***Source:*** *authors' own elaboration based on Veloso (2001), Kuntze and Moerenhout (2013); Johnson, (2016).*

### 3.2.1. MARKET SIZE AND STABILITY

RE auction schemes are typically accompanied by specific targets for the deployment of energy programs within a certain period (e.g. in the form of the expected annual average installed capacity), which corresponds to the total volume auctioned in specific bidding windows (IRENA, 2018). This is referred to as the auction demand, which constitutes the expected market for prospective technology and equipment suppliers that are considering entering the market by investing in local production units in order to comply with the LCRs. It has often been argued that a sizeable market is needed in order to encourage investments in local manufacturing plants (see e.g. Lewis and Wiser, 2007). The size of the market demand determines whether investors are able to reach economies of scale and produce components at competitive prices locally (Kuntze and Moerenhout, 2013; Johnson, 2016). The investment decision thus involves evaluating whether the expected market demand will be sufficient to justify investing in local production units compared to the sourcing of components produced locally from external suppliers or importing them from abroad. If the anticipated market demand is considered too small, technology suppliers may simply refrain from entering the market. A related factor influencing the effectiveness of LCRs is the long-term stability of the market demand. In order to attract investments, the level of market demand should be predictable in the long term by providing a stable and foreseeable planning horizon for prospective investors. Predictability may be encouraged by sending strong political signals to provide the certainty of a continuous and steadily growing market. Without predictable and stable long-term market demand, technology suppliers may consider investments too risky and decide not to invest in local manufacturing.

### 3.2.2. POLICY DESIGN AND COHERENCE

The design and implementation of the auction scheme have been found to play a central role in the ability of LCRs to promote local manufacturing. In general, the literature points to the need for LCR policies to provide clear rules and regulations that can be enforced effectively during implementation of the auction system. Indeed, clear definitions of the LCRs, together with transparent and un-bureaucratic procedures for complying with the requirements, are needed to reduce the risk of unforeseen costs and economic losses for investors. In particular, during policy implementation, the existence of loopholes in the policy design may lead project investors to search for ways to circumvent, avoid and navigate around the LCRs (Baker and Sovacool, 2017). Indeed, poorly defined LCRs may leave too much room for interpretation, which may significantly reduce the efficiency of the LCRs to promote local manufacturing (Johnson, 2013). This is essentially a question of clearly defining and strictly enforcing what counts as locally produced content under the LCRs (IRENA, 2015). However, the literature also points to a need for the government agencies involved in managing and administering the LCRs to adopt a flexible approach involving continuously monitoring progress on the ground in order to adapt and adjust the policy as circumstances change and unexpected events occur (Johnson, 2016). Relatedly, LCRs may often not be effective if used in isolation or in non-alignment with other policies. Indeed, the effectiveness of LCRs in promoting local manufacturing in targeted sectors may depend critically on the degree to which they are aligned with complementary policy instruments. In particular, as argued by Lewis and Wiser (2017), the effectiveness of LCRs may depend critically on their alignment with a supporting industrial policy framework. Hence, a coherent and coordinated effort across different policy areas may be needed to pursue a common direction and prevent counteracting initiatives.

### 3.2.3. RESTRICTIVENESS

In the literature, restrictiveness refers to the levels of LCRs in terms of the percentages of local content required under the LCR policy (Kuntze and Moerenhout, 2013). LCRs are typically introduced at a relatively low level, such as 30%, after which the levels may increase successively, for example, to 50% and even 70%, in parallel with the implementation of the auction scheme. These percentages are often formulated as minimum threshold requirements, but they may also be used in auction schemes as a parameter in assessing bids (Eberhard et al., 2014). For investors, the LCR's levels or percentages directly influence the economic costs of sourcing or producing components locally, which translates into overall project costs. Indeed, components may often be sourced and imported at a lower cost from the global market. Hence, if the LCRs are too high, they may risk jeopardising the overall economic efficiency of the auction scheme (Johnson, 2016). Conversely, if they are set too low, they may create

bureaucratic obstacles and increase transaction costs without increasing the use of locally produced components. Consequently, auction designers are confronted with a difficult choice in identifying an appropriate or optimal balance in LCR levels during the scheme's implementation. Ideally, this balancing act creates the economic incentives needed to achieve the dual targets of promoting local production while ensuring the overall economic efficiency of the auction scheme. The timing of changes in the LCRs is central in this regard, including their possible withdrawal, which may require a planned evaluation process involving close monitoring of their effects over time.

### 3.2.4. INDUSTRIAL BASE

Finally, the level of technological capabilities and competences in local industries can play a role in the effectiveness of LCRs. Such capabilities in the local industrial base may already exist in related areas of manufacturing, but they may also be developed over time as learning effects may accrue in parallel with increasing technology deployment (Steinhilber, 2016). Foreign technology suppliers typically consider the skills of local suppliers to be a central element in their considerations concerning whether to source locally produced components from existing suppliers or to invest in their own manufacturing plants (Kaplinsky and Morris, 2003). Indeed, a strong industrial base with local firms operating close to global market standards in terms of production capacity, economic efficiency and cost competitiveness means that components and products can be sourced locally at competitive or low additional costs. Accordingly, relatively high levels of technological capability both nationally and at the firm level are likely to encourage foreign direct investment as a form of market entry ensuing that foreign technology suppliers comply with the LCRs (Rennkamp and Westin, 2013). In the case of non-existent or low-quality local manufacturers, LCRs are likely to be ineffective in promoting the establishment of new local manufacturing plants (Veloso, 2001; Río, 2017). In other words, a minimum level of domestic manufacturing capabilities may be required for LCRs to be effective.

# 4. EXPLORING THE EFFECTIVENESS OF LCRs

The following will present the main findings in the literature on the effectiveness of LCRs in promoting local industrial development in relation to onshore wind and solar PV power in South Africa, Brazil, India and China.

## 4.1. SOUTH AFRICA

In South Africa, a number of studies have assessed the effectiveness of the LCRs included in the so-called Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in establishing the local production of solar PV and wind turbine components (Ettmayr and Lloyd, 2017). In relation to wind turbines, Larsen and Hansen (2017;22) found that "*the establishment of local production of key wind turbine components has only made relatively limited progress*" due to the limited number of local manufacturing plants established and the low-value added nature of the components produced locally (see also Matsuo and Schmidt, 2019). Indeed, only three local wind turbine tower manufacturers have been identified by various studies, and local production of high-value added wind-turbine components, such as blades or nacelle components, have been found to be absent (Rennkamp and Boyd, 2015). As reported by Steffens (2018;90), "*only towers as components with low technology content are produced locally*" (see also Probst and Dechezleprétre, 2018). Baker and Sovacool (2017) pointed to the establishment of a local blade-manufacturing plant in South Africa in 2010, which was later liquidated in 2013, while Rennkamp and Boyd (2015) reported that a previous plan from 2013 for an international blade manufacturer to establish a local factory was aborted in 2015.

With regard to solar PV, Baker and Sovacool (2017) found that a total of seven local solar PV assembly factories have been established in South Africa, two by the Chinese companies Jinko Solar and Wuxi Suntech, involving respectively a solar module assembly factory and a new warehouse

facility. Four other solar panel and module assembly plants and a local inverter factory were also set up by various European companies. While few studies have specifically analysed the effectiveness of LCRs on the establishment of local solar PV manufacturing plants in South Africa, McDaid (2014) concluded that, in relation to solar PV and wind turbines, "*little local manufacturing and sustainable local economic development has been realised to date*". This conclusion resonates with Morris and Martin (2015;64) who found that "*we have not seen an increase in domestic industrial content and hence an increase in the number of locally based manufacturing firms spun off from this sector*". In contrast, Baker (2017;109) argued that the "*RE IPPPP's local content requirements .. have helped to facilitate the establishment of a number of manufacturing and assembly plants mainly for wind towers, solar PV panels and invertors*". So, while there seem to be disagreement over whether the LCRs have been effective in promoting the localisation of wind turbine and solar PV component manufacturing plants in South Africa, there seem to be agreement over the exact number of local manufacturing plants that have been established.

## 4.2. BRAZIL

In Brazil, a number of studies have analysed the effectiveness of LCRs in promoting local production of solar PV and wind-turbine components. IRENA (2013;43) found that in Brazil "*the emergence of local wind manufacturing companies testifies to the fact that these auctions have been successful in promoting the growth of the domestic wind industry*". Further, OECD (2015;63) pointed out that "*in Brazil, the LCR policy has incentivised the domestic production of low- and medium technology content, but not of high-technology components of wind turbines*". Rennkamp and Westin (2013;2) found that under the LCRs for wind turbines in Brazil, "*parts of the nacelle, hubs and blades have increasingly been manufactured locally*", and reported a total of "*15 manufacturers that supply most of the components for the Brazilian wind energy sector*". These local producers mostly involve local affiliates and subsidiaries of foreign suppliers of components with varying degrees of complexity, such as Acciona (hub assembly), Alstom (nacelles), Impsa (nacelles and blades) and Enercon (nacelles, blades and towers). IRENA (2013;21) noted that "*only one* [wind turbine] *manufacturer was operating at the time*" of the first round of the auction scheme in 2007, which did not include wind power (see also Río, 2017). However, Rennkamp and Westin (2013;14) found that subsequent to the inclusion of wind power in the auction scheme in 2009, the LCRs of 60% for wind power "*attracted a new generation of manufacturers in the period between 2009 and 2012*". Hochstetler and Kostka (2015;82) noted that "*by 2014, there were four manufacturers of wind turbines and seven turbine assemblers in Brazil, along with thirteen manufacturers of towers and thirteen of parts and components*". Accordingly, the above studies appear to agree that the establishment of new local wind turbine component factories in Brazil was directly attributable to the implementation of the LCRs under the auction scheme. Indeed, as stressed by Rennkamp and Westin (2013;19), "*In the Brazilian case, the local content requirements contributed to establishing an industry for components for local and medium technology content*". Similarly, IRENA (2013;22) found that "*the entrance of General Electric, Alston, Vestas, Siemens, Suzlon and Gamesa to the Brazilian market .. testifies to the fact that auctions have contributed to the growth of the domestic wind industry*".

In relation to local production and assembly of solar PV components in Brazil, OECD (2015;52) reported that the LCRs for solar PV adopted in Brazil (in 2014) stipulated that "*until 2017, projects receiving funding must use PV modules assembled in the nation using locally produced frames*". Concerning the effectiveness of the LCRs, Transfer LBC (2015;15) noted in 2015 that "*in terms of the current situation upstream, however, there is still very little in place. There is only one factory able to assemble solar panels, TECNOMETAL with capacity for 25MW/year in Minas Gerais, and it is often idle*". However, it appears that subsequent studies have generally reported the LCRs as having greater effectiveness. De Souza and Cavalcante (2016;146;151), for example, found that the "*local content rule incentivized the establishment of PV factories*" .. "*besides .. RIMAS and Minasligas, which supply a large volume of metallurgical grade silicon—the national production consists basically of module manufacturers (e.g. Tecnometal and Globo Brasil)*". Further, Held (2017;27) stressed that "*the fact that no local module supplier was available in Brazil three years ago indicates that the*

*supply chain matured tremendously over the years. Tecnometal, for instance, used to be the only large module supplier for a long time*". Indeed, in 2017 the Brazilian Photovoltaic Solar Energy Association (ABSOLAR) listed thirty-four local producers of solar PV components accredited under the LCR system, consisting of six module manufacturers, ten system assemblers, eight inverter suppliers, six trackers and four suppliers of junction boxes. According to Held (2017), module manufacturers include the establishment in 2016 and 2017 of two local solar module assembly facilities in Brazil by Canadian Solar and the Chinese company BYD respectively. In summary, the above studies seem to point to the great effectiveness of the LCRs in promoting local assembly of solar PV modules over time in Brazil.

## 4.3. INDIA

The so-called National Solar Mission (NSM) policy in India, which was implemented in two phases: 2010-13 and 2013-17, included LCRs specifically for solar PV. Indeed, according to Azuela et al. (2014a;16), "*the auction rules explicitly established a hard domestic content requirement (DCR) on crystalline silicon PV modules to support the manufacturing of this technology in India*". However, several studies have highlighted the limited effectiveness of India's LCRs for solar PV in promoting the local assembly of cells and modules based on crystalline silicon (c-Si). OECD (2015;62), for example, found that "*the LCR policy has allowed domestic c-Si manufacturers to capture only 3-7% of India's solar market, much less than initially planned*". Evidently, the LCR policy created a bias towards thin-film imports as opposed to locally manufactured c-Si cells and modules, which meant that "*more than 70% of India's solar-PV capacity now uses imported thin-film panels*" (OECD, 2015;62). Similarly, Hufbauer et al. (2013;88) found that "*the LCR has failed to accomplish its goal. By shifting market share from CSi to thin film .. without creating very much domestic manufacturing*". Further, Johnson (2013;20) reported the effects on India's existing c-Si manufacturing firms as follows: "*Receiving few local orders and hit by falling exports to EU and US, which had previously been their main markets and the reason for their establishment, local manufacturers, such as Tata BP Solar, Indosolar and Moser Baer suffered heavy losses*". However, while most studies agree that the LCRs did not live up to initial expectations in terms of promoting local production of solar PV, there are reports that the local c-Si manufacturing industry expanded significantly as a consequence of the LCRs. Verma and Kumar (2018;2), for example, found that, "*since the inception of the National Solar Mission, the module manufacturing industry has seen significant growth. The manufacturing capacities for cell and module had increased to approximately 3.2 GW and 8.4 GW in 2017 (from 45 MW and 80 MW in 2007) respectively*". In a similar vein, Verma et al. (2017;7) stressed that "*India has also doubled its module manufacturing capacity from 2.8 GW in 2014 to 5.7 GW in 2015. At present, India has 94 PV module manufacturers*". On the importance of LCRs in this regard, Hufbauer et al. (2013;106) argued that "*the LCR is likely responsible for some of the growth in India's CSi manufacturing*", while Johnson (2013;21) stressed that, "*according to interviewees at MNRE and within the PV industry, by 2012, local manufacturing capacity had increased*". Similarly, Johnson (2016;191) highlighted that "*it is clear that LCRs – as they were designed in Phase 1 of India's NSM – were partially successful in promoting domestic manufacturing, as they appear to have helped Indian manufacturers weather some of the storm that has hit the global manufacturing industry*". Finally, Shrimali and Sahoo (2014;501) provided nuances to this understanding by highlighting the fact that "*the first, and weaker, version of the policy accomplished its intention of promoting domestic crystalline silicon modules. However, the second, and stricter, version of the policy has not been as effective: it appears to have promoted the use of foreign thin film modules instead*" (see also Sahoo and Shrimali, 2013). In summary, it appears that the LCRs for solar PV supported local c-Si manufacturing in India to some extent, although not as much as foreseen by policy-makers. While there are indications that the LCRs encouraged existing c-Si manufacturing firms to sustain and expand their business activities, previous studies do not provide clarity on the extent to which they enabled the establishment of new local production facilities.

## 4.4. CHINA

According to Lewis (2007), from the late 1990s until 2000 in China LCRs specifically for wind turbines were at 40%. However, the RE auction scheme implemented in 2003-2009 initially included an LCR for wind power of 50% in 2003, which in 2004 was increased to 70%, after which the LCRs accounted for 20% to 35% of the bid evaluation scores. The last tenders were issued in 2007, and the LCRs were subsequently eliminated in 2009 (IRENA, 2013). Various studies have pointed generally to the importance of the auction scheme's LCRs in promoting the development of domestic wind turbine manufacturing in China. Kuntze and Moerenhout (2013;15), for example, found that "*China's LCR for wind energy scored well in terms of fostering the infant wind energy industry*". Similarly, IRENA (2013;28) stressed that "*the local content requirement on onshore wind .. played a significant role in the development of the domestic wind industry*". Echoing this, Lewis (2011;300) stressed that in China "*local content requirements and preferential project selection for Chinese manufacturers have been instrumental in helping them build an industry*". A number of studies highlight that the initial growth in the domestic manufacturing industry caused by the LCRs mainly involved production facilities owned by foreign companies. Lewis (2007;3), for example, argued that "*these local content requirements are causing foreign firms .. to develop a manufacturing strategy that will allow them to meet these requirements. Consequently, many leading international wind turbine manufacturers are either establishing local manufacturing facilities or assembly facilities for Chinese-made components*". Similarly, Steinhilber (2016;13) suggested that the LCRs encouraged that "*production facilities were set up in China by leading manufacturers such as Vestas, Suzlon, Gamesa, and GE*". Later on, however, Chinese-owned wind turbine manufacturing firms became more prominent. Indeed, according to Kuntze and Moerenhout (2013;15) "*before 2000, Chinese companies held only 10% of the domestic market share*" [whereas] "*the top ten Chinese companies accounted for 85.3% of newly installed capacity in 2009*". In summary, most studies agree that the LCRs had a decisive influence on the development of the domestic manufacturing industry. However, no studies have analysed the number of new production facilities established or the expansion of existing ones that can be attributed to the LCRs.

In summarising the above, it appears that previous studies have generally ascribed importance to the role of LCRs as a key factor in promoting the establishment of local wind and solar PV manufacturing plants across the countries and technologies analysed. However, variation across the previous studies can also be observed both within and between the countries and technologies we are investigating with regard to the effectiveness of the LCRs.

# 5. FACTORS DETERMINING THE EFFECTIVENESS OF LCRs

As described above, the effectiveness of LCRs in terms of promoting local industrial development has generated mixed results across the countries and technologies we examined. In this section, we provide a description of the main determining factors highlighted in the literature to account for these differences.

## 5.1. MARKET SIZE AND STABILITY

The enormous size of the Chinese market has often been referred to as a main driver enabling LCRs to be effective in promoting the establishment of local wind turbine manufacturing. OECD (2015;63), for example, pointed at "*the size of public tenders; .. China's large wind-energy potential;* [and] *the market size of China's manufacturing sector*" among the main conditions underlying the high degree of effectiveness of the LCRs in China. Similarly, Kuntze and Moerenhout (2013;17) argued that "*the growth of Chinese manufacturers and their excellent performance in recent global statistics is largely due to the combination of the LCR with a large domestic resource and demand*". Further, GWEC (2012;7) pointed out that, "*although China used LCR for promoting its wind industry,*

*the underlying factors that allowed this tool to be successful were extraordinarily diverse. China has an enormous domestic wind energy resource. But most important is the enormous size of the market*”[1]. The size of the domestic market was set specifically by the political targets for wind power under the auction scheme (Azuela et al., 2014a). In 2001, the Chinese government set a target for 500 MW of wind power to be reached in 2006, while in 2007 a target for wind power was set for 5,000 MW to be reached by 2010 (Walz, 2018). According to OECD (2015), this politically created demand was sufficient to attract and encourage businesses to invest in local production in order to comply with the LCRs (see also Lewis, 2011)[2]. As pointed out by Kuntze and Moerenhout (2013,15) “*the value of its immense domestic market and financial incentives did not deter foreign companies, who decided to comply with the .. LCRs in order to become players in the Chinese market*”.

In contrast, the limited effectiveness of the LCRs for wind power in South Africa has partly been explained by the comparably limited size and instability of the demand for wind power (Matsuo and Schmidt, 2019). Indeed, according to DTI (2015) the demand needed for companies to justify establishing the local production of wind turbine blades, for example, was estimated to be in the range of an average annual installed capacity of around 800-1,000 MW (see also Leigland and Eberhard, 2018). However, under the auction scheme the government set a target for annual average installed capacity at 677 MW until 2020, after which the demand would decrease to 467 MW annually. Accordingly, the expected size of the market was evidently not sufficient to attract companies to establish local production (Morris and Martin, 2015). To this comes the unpredictable nature of the auction scheme. As argued by Larsen and Hansen (2017;19): “*uncertain political signals about future market demand that appeared in political discussions .. did not provide the predictable and long-term planning horizon necessary for investors to proceed with plant investments*” (see also Leigland and Eberhard, 2018). Relatedly, Rennkamp and Boyd (2015;22) stressed that: “*the case of wind energy shows that the REIPPPP and its local content requirements are not designed to develop a local industry, because market access is very limited for start-up firms*”. Similarly, with regard to solar PV, Baker and Sovacool (2017;8) stated that “*solar PV manufacturers have argued that the allocation of approximately 600 MW for solar PV within each round of RE IPPPP has been insufficient to encourage the development of a local industry*”. Further, in their comparison of the effectiveness of LCRs in the wind sectors in South Africa and Brazil, Rennkamp and Westin (2013;3) concluded that “*content requirements are not an effective industrial policy by themselves, but need a significant market size* [since] *the Brazilian case demonstrates that the international investment took off with the allocation of a significant market size. The South African program, in turn, makes small and short-term provisions for wind energy*”. Echoing this, Azuela et al. (2014b;3) argued that “*with periodic auctions providing a steady stream of newly contracted wind power projects, the wind equipment industry in Brazil flourished. Several manufacturers of wind turbine components set up factories in the country*”. During the initial phase of the auction scheme, however, the LCRs for wind in Brazil were according to Rennkamp and Westin (2013;9) less effective since at that point in time, “*the market was too small and too instable for other international competitors to invest*”.

In relation to the auction scheme for solar PV in India, Johnson (2016;188) argued that, while a “*stable demand was always considered a weakness of India’s energy system* [the auction scheme] *certainly increased the size and stability of the solar PV market by catalysing demand*”. Further, Johnson (2016;189) noted that “*the large market opportunity made LCRs a favourable option* [as] *the use of LCRs in a market with relatively large demand was at least partially successful in helping many firms stay afloat*”. Similarly, the size of the demand in Brazil for solar PV appears to have enabled the LCR to be effective in contributing to localising the production of solar cells and modules. Indeed, as pointed out by Held (2017;27), “*at least 500 MW solar delivery contracts must be awarded annually to justify investments in new production facilities. Considering the fact that more than 2,6 GW have been contracted through previous auctions, the criteria has been more than fulfilled to justify supply chain investments*”. Further, as argued by Transfer LBC (2015;15), “*with the sale of almost 900 MW through government auctions that guarantee their price for 20 years, finally a stable demand of significant size was created .. another auction for approximately 1GW was announced to take place in August 2015. Local content requirements ... makes it feasible to expect that solar cells will be manufactured in Brazil in 2020*” (see also de Souza and Cavalcante, 2016). Finally, Held (2017;11) pointed to “*the importance of a regular and stable demand for solar panels in respect to the development and sophistication of a mature solar supply chain in Brazil*” as a precondition for the high effectiveness of the LCRs.

## 5.2. POLICY DESIGN AND COHERENCE

While, according to Kuntze and Moerenhout (2013), the LCRs for wind power in China were enforced in a stringent manner, the government agencies involved adopted a flexible approach involving close monitoring of progress on the ground during implementation of the auction scheme. This approach evidently enabled a gradual phasing out of the LCRs in parallel with the development and strengthening of capabilities in the domestic wind turbine manufacturing industry. Indeed, as pointed out by IRENA (2015,35) "*China.. adopted LCR clauses in its early mechanisms for fostering renewable energy, but as the country's wind equipment industry flourished, these constraints were deemed no longer necessary*". Further, the reported high effectiveness of the LCRs in China in developing a domestic wind turbine manufacturing industry appear to have depended critically on the existence of complementary policies pursuing similar objectives. As pointed out by Lewis (2011;300), under the auction scheme. "*companies in China .. benefited from not only policy support for wind power deployment but also direct support for local manufacturers*" (see also Binz et al., 2017).

In contrast, in South Africa the LCRs for wind and solar power appear to have been less well-defined and implemented in the absence of additional supplementary policies. As stated by

Reenkamp and Boyd (2015;25), "*the South African government has defined the numbers, but has left implementation to firms and has not provided a significant level of support. Trying to create local industries only through local content requirements is difficult*". Similarly Leigland and Eberhard (2018;582) argued: "*nor was the government seen to be pursuing any kind of coordinated public policy effort beyond REIPPPP to promote manufacturing of these technologies*". Concerning the definitions of LCRs, Morris and Martin (2015;64) stated that "*these local content requirements were principally met through procuring a variety of non-critical inputs and services which did little to foster new trajectories of domestic industrialisation*". Similarly, Baker and Sovacool (2017;4,6) argued that "*loopholes in these regulations have resulted in a number of solar PV developers sidestepping them and importing stock from abroad* [since] *the lack of clarity over local content rules and definitions .. enabled international project developers .. to exploit and manipulate loop holes*". Accordingly, the imprecise nature of the LCRs provided too much room for speculation, which appear to have hindered their effectiveness in promoting local production of wind turbine and solar PV components in South Africa (Leigland and Eberhard, 2018). In combination with the absence of complementary policies, Reenkamp and Boyd (2015;22) concluded that the LCRs specifically for wind power in South Africa could have benefited from "*clear implementation rules .. and an integrated policy approach for innovation and industrial development*". Finally, Leigland and Eberhard (2018;584) pointed to a deficient enforcement of the LCRs in South Africa by stressing that, "*without a substantial number of permanent professional staff and an ongoing government budget allocation to cover performance monitoring and evaluation costs, it is difficult to see how this monitoring work can be sustained at an appropriate level*".

Loopholes and inconsistencies in policy design have also been highlighted as key factors limiting the effectiveness of the LCRs for solar PV in India. As pointed out by Johnson (2016;189), "*India's LCR policy design contained a significant loophole ... the policy was designed to omit thin film technology from LCR rules. This loophole made thin film ... the increasingly preferred option, thereby weakening the intended impact of the LCR in catalysing greater use of locally manufactured technology*" (see also Shrimali and Sahoo, 2014). This ambiguity in the policy design enabled the importation of thin film solar panels at comparably lower costs, which contributed to reducing the effectiveness of the LCRs in promoting domestic production of silicon-based solar PV. To this comes the apparent misalignment between the LCRs and other energy and industrial policies of relevance. Indeed, Johnson (2016;190) stated that "*there were significant overlaps and lack of coordination between policy mechanisms, leading to limited transparency and fiscal discipline, convoluted processes for claiming subsidies, and weakened impact. We can therefore conclude that policy coherence was rather limited*". Indeed, in some cases the LCRs appear to have been in direct conflict with trade-related policies in India: imports of input materials to assemble solar modules faced an import duty of around 13%, whereas imports of pre-assembled modules were exempt from import duties (Johnson, 2013).

In Brazil, the LCRs for wind power were defined not only in terms of value, but also as the percentage of the total weight of the turbine. This definition of the LCRs was found to be instrumental in their effectiveness. For example, OECD (2015;63) stressed that "*the LCR is linked to the weight of the wind turbine components. This further increases the stringency of the LCR, and forces developers to source the majority of wind turbine towers locally*" (see also Andreão et al., 2017). Further, Kuntze and Moerenhout (2013;28) pointed out that "*LCRs are coupled with the weight of the different components, which means that wind turbine towers must be de facto produced within Brazil (they often account for around 80% of a turbine's total weight)*". However, Reenkamp and Westin (2013;3) found the lack of "*complementary technology policy support*" to have hindered the effectiveness of the LCRs in promoting local production of wind turbine components. Similarly, the effectiveness of the LCRs for solar power in Brazil also appears to have been hindered by ambiguities in the policy design concerning locally produced content. Consequently, the LCRs for solar power were revised in 2017 with a view to clarifying and simplifying the rules, particularly concerning the methods used by project developers to calculate the mandatory and optional solar PV components to be produced locally. As argued by Held (2017;16): "*the new schedule is much easier to read and only differentiates between mandatory .. and optional .. accreditation items* [while] *simplifying the rules .. increase flexibility* [and] *reduce the scope of obligations*". Finally, it appears that the LCRs adopted under the auction scheme for solar power was the only policy instrument aimed at developing a domestic solar PV manufacturing industry in Brazil (see also Transfer LBC, 2015). As pointed out by Andreão et al. (2017;10), this has decreased the effectiveness of the LCRs, since "*maintaining solar auctions every year are good measures, but they are not enough for the nationalization of this technology supply chain*".

## 5.3. RESTRICTIVENESS OF LCRs

Generally, the literature points to the increasing restrictiveness of LCRs as having a direct effect on the degree to which local manufacturing is established and the degree to which components with higher value-added content are produced locally. Various studies have argued that the high effectiveness of the LCRs in localising wind turbine component production in China were directly related to the rapid and significant increase in the level of LCRs from 50% in 2003 to 2004 to 70% in 2005 to 2009. For example, Kuntze and Moerenhout (2013;15) argued that "*the combination of a steep rise in deployment and LCR led to the development of a Chinese manufacturing industry*" (see also Lewis, 2011). Indeed, the rapid and significant increase in the LCRs is unprecedented compared to those adopted under the auction schemes implemented across the countries and technologies examined in this paper.

In South Africa, the LCRs for wind power involved a successive increase in the minimum threshold requirement for locally-produced content across the four bidding rounds from 2011 to 2015: 2011 (25%), 2012 (35%), 2013 (40%) and 2015 (40%). As a consequence of the increase in the level of the LCRs, the share of locally produced content increased from an average of 27.4% in round 1 to 48.1% in round 2 and to 46.9% in rounds 3 and 4 across the constructed projects (DTI, 2015). Furthermore, the components produced and sourced locally shifted from low value-added components, such as locally produced cables and wires, in the first round to include comparably higher value-added components, such as towers, in the second round (Rennkamp and Boyd, 2015). However, the components produced locally did not advance to the highest value-added components, such as blades and nacelle components (including gearboxes, generators and pitch systems) (Larsen and Hansen, 2017). The LCRs for solar PV in South Africa involved a similar increase in the minimum threshold levels across the four bidding rounds from 2011 to 2015: 2011 (35%), 2012 (35%), 2013 (45%) and 2015 (45%) (Ettmayr and Lloyd, 2017). Consequently, the share of locally-produced content increased from an average of 38.4% in round 1 to 53.4% in round 2, 53.8% % in round 3 and 62.3% in round 4, mainly in the form of the local assembly of modules (Eberhard and Naude, 2017; Baker and Sovacool, 2017).

In Brazil, the LCRs for wind power were introduced at a relatively high level of 60% in 2009, which was maintained until 2012: as argued by Kuntze and Moerenhout (2013;28) "*the 60% LCR was rather stringent from the beginning*". Subsequently, from 2013 onwards, according to OECD (2015;52)

the auction scheme required manufacturers "*to obtain locally at least three of the four main wind-farm elements (i.e., towers, blades, nacelles and hubs)*" (see also Viana and Ramos, 2018). Hence, the restrictiveness of the LCRs appears to have increased over time, which, according to Reenkamp and Westin (2013;14), meant that prospective component suppliers "*quickly needed to invest into factories to be able to catch up with the local content requirements*" (see also Bayer, 2018). Consequently, the number of local component manufacturers increased, while the locally produced components themselves shifted from towers to blades to more complex and higher value-added components, such as nacelle boxes, hubs and electric equipment. Based on previous experience with the LCRs for wind power, the minimum percentage required in 2014-2017 was also set at a high level of 60% for solar PV. Evidently, the calculation methods pertaining to the LCRs encouraged project developers to source higher value-added components produced locally, such as junction boxes, inverters and cells, as opposed to activities involving a comparably lower value-added content, such as module assembly (Held (2017)[3]. However, according to De Souza and Cavalcante (2016), it appears that the relatively restrictive LCRs were mainly effective in stimulating the local assembly of modules.

Finally, the first phase of the auction scheme for solar power in India involved (in Batch I) LCRs at a similarly high level of 60% for the domestic assembly of modules using crystalline silicon cells (OECD, 2015). Subsequently, in Batch II of the first phase, the LCRs also applied to the local manufacture of crystalline silicon cells, which, according to Johnson (2016;186), suggested that "*the government hoped a year would be sufficient to develop greater cell manufacturing capabilities from experience in module assembly*" (see also Johnson, 2013). Hence, as noted by Shrimali and Sahoo (2014;508), with the increasing focus on the local manufacture of cells, the restrictiveness of the LCRs increased: "*the requirements were tightened from Batch I to Batch II of Phase I*". However, according to Johnson (2013), it appears that the increase in the restrictiveness of the LCRs was mainly effective in promoting the local assembly of modules.

## 5.4. INDUSTRIAL BASE

Several studies have stressed that the level of the technological capabilities of domestic suppliers is a key factor influencing the effectiveness of the LCRs. In relation to wind power in China, for example, some experience in wind-turbine manufacturing had been accumulated prior to the introduction of the LCRs under the auction scheme in 2003. As pointed out by Kuntze and Moerenhout (2013;14), "*in 1996, it* [China] *had only 56.6 MW of wind power in place.. This went up to 166.6 MW in 1997 and 468 MW in 2002*". More important, however, were the existing competences in project management and engineering in related industries in China, especially in heavy-machinery manufacturing (including power-generating equipment). Indeed, according to Hansen and Lema (2019;254), "*the Chinese wind turbine industry also benefited from a prior industrial base in heavy machinery industries and related engineering competences, which enabled existing firms to diversify into wind turbine manufacturing* (see also Binz et al., 2017). The reported high effectiveness of the LCRs in promoting the development of a domestic wind turbine industry in China thus appears to have been favoured by existing industrial competences.

With reference to the effectiveness of the LCRs in encouraging foreign technology suppliers to establish local wind-turbine manufacturing in South Arica, Rennkamp and Westin (2013;19) stated that: "*the national technological capability is limited, which increases technology prices and makes it increasingly difficult to invest into a local industry*". Since the domestic wind power industry was confined to a few small-scale demonstration projects prior to the introduction of the auction scheme in 2011, existing competences in wind-turbine manufacturing and related engineering were reportedly limited. This meant that, as the first locally produced wind turbine towers began to materialise, it was difficult for the domestic suppliers to meet their buyers' quality standards and specifications (Baker and Sovacool, 2017). Consequently, as pointed out by Larsen and Hansen (2017;22), some of the established manufacturing plants were liquidated: "*the closure of the plant developed by the domestic company reflects the high quality requirements and the consequent need for highly specialised capabilities and expertise that is difficult to build in a short timeframe*". In addition, the production

capacity of the few existing companies specialised in related manufacturing sectors was limited. The example presented in DTI (2015;77) serves as an illustration: "*DCD's manufacturing capacity of 110 towers per annum .. is not sufficient to meet the current demand in the market*". The effectiveness of the LCRs in developing a domestic wind turbine manufacturing industry thus appears to have been hindered by the limited pre-existing industrial base. A similar picture emerges with regard to solar PV in South Africa. As pointed out by Baker and Sovacool (2017;4), "*the country does not have a well-established industry for the manufacture of renewable energy equipment .. or indeed manufacturing more generally*". Ahlfeldt (2013), however, points out that there was already a certain level of manufacturing capabilities in local module assembly in South Africa, mainly related to small-scale rooftop systems as opposed to utility-scale solar power plants (see also Rennkamp and Westin, 2013)[4].

Alluding to the limited solar PV manufacturing capacity in the domestic industry in India prior to the introduction of the auction scheme, Johnson (2016;191) noted that, "*when the NSM began, the innovation ecosystem in India was fairly weak*". Similarly, Hufbauer et al. (2013;91,92) argued that "*before the JNNSM, the Indian solar manufacturing sector was very small*", and pointed out that "*Indian manufacturers do not employ the best technology… require additional training, manpower, and skilled technical workers* [and] *lack economies of scale*". The limited domestic manufacturing capacity appears to have hindered the effectiveness of the LCRs in India. However, Shrimali and Sahoo (2014;508) stressed that, given the pre-existing level of industrial competences, the LCRs "*may be able to expand module manufacturing* [but] *may be unable to expand cell manufacturing* [which] *is the more complex step*" (see also Johnson, 2013).

Prior to the introduction of the auction scheme in Brazil in 2009, the domestic wind turbine manufacturing industry consisted of a single wind turbine supplier (IRENA, 2013). However, the domestic steel industry was relatively well-developed, which provided a conducive basis for local suppliers of steel structures to diversity into the production of wind turbine towers. This circumstance, according to Reenkamp and Westin (2013), was a key precondition for the effectiveness of the LCRs in promoting the domestic manufacture of wind turbine components. Finally, concerning the introduction of the auction scheme for solar power in 2014 in Brazil, de Souza and Cavalcante (2016;9) argued that "*the domestic solar PV industry in Brazil is still fairly undeveloped, with actors missing along many stages of the value chain*". Similarly, Held (2017) pointed to the low number of existing solar assembly plants and limited industrial competences in related areas (see also Transfer LBC, 2015), which appear to have hindered the effectiveness of the LCRs.

# 6. DISCUSSION

Most of the studies reviewed in this paper have ascribed importance to the role of LCRs in stimulating the establishment and nurturing of the domestic production of wind turbine and solar PV components as part of auction schemes. However, it is difficult to ascertain exactly how effective the LCRs have been due to a lack of a common methodology to examine this question across the previous studies. In most cases, the effectiveness of the LCRs is addressed at the overall and aggregate level, mainly through the use of anecdotal evidence to measure the "maturity" or "degree of development" of the domestic industry without explaining how the respective studies arrived at such conclusions. Indeed, the measures and indicators used to assess locally produced content differ across studies and are seldom explained or clarified in detail. Consequently, the literature does not provide a perspective for assessing when LCRs may be considered to have been effective. For example, how many local manufacturing units should be created in a given country or sector for the LCRs to be considered effective? From a political point of view, addressing this question logically involves considering the political objectives and the specific conditions of the auction scheme. From an academic perspective, it appears that there is a need to develop a common set of parameters for analysing LCR effectiveness in order to allow for more systematic comparisons. This paper serves as a starting point in developing such a perspective that distinguishes more clearly between the various observed effects of the LCRs, such as the number of new production facilities created or the diversification of existing ones.

Based on the empirical findings presented above, the LCRs could be considered to have been most effective in the case of the development of the wind turbine manufacturing industry in China. Indeed, the remarkable speed at which a large number of domestic wind-turbine suppliers emerged to capture the major share of total installed capacity over the relatively short period of the auction scheme is often highlighted as a key feature of the LCRs in China (Lewis and Wiser, 2007; Lewis, 2011). Subsequently, some of the key suppliers, including Goldwind and Sinovel, went on to becoming prominent global players. It appears that all the determining factors enabling the LCRs to have this effect were in place in China, including a sizeable and stable market, a pre-existing industrial base and various complementary policies. However, this should not be interpreted to mean that the effectiveness of LCRs in the wind turbine industry should be evaluated against China as the benchmark. For example, the reportedly high effectiveness of the LCRs in Brazil in developing a wind turbine manufacturing industry may be considered a valid observation, despite it not having taken place at the speed and scale at which the Chinese wind turbine industry developed.

The paper give rise to reflections about the determining factors put forward in the existing literature to assess the effectiveness of LCRs. While the specific factors of interest in this paper provide a useful framework for assessment, various other influential factors of importance are certainly overlooked. Examples include exchange rate fluctuations, changing financing conditions, customs procedures, corruption and the protection of intellectual property rights, all of which are disregarded in the existing framework. In addition, it appears that there is a need to specify further how the determining factors in the framework operate at the micro-level. While most studies direct attribute promotion of the establishment of local production to the LCRs, this is typically not assessed in detail through in-depth research at the firm level. However, for both domestic and foreign companies considering establishing local factories under the LCRs, a range of managerial and operational aspects may be taken into consideration. While the management decisions may include considerations of elements of the framework, such as the size and stability of the market, a range of additional firm-specific factors may be taken into consideration, such as staffing, social responsibility, strategy and competitiveness parameters. Further research could thus benefit from analysing how individual companies respond to the LCRs from a management perspective. Such research could address the relative importance of the determining factors over time. For example, predicted market demand and the existing industrial base may play a crucial role initially, but the restrictiveness of the LCRs may become more important later on.

Finally, in most cases the LCRs focus on local content in the form of tangible goods manufactured locally, a perspective that also prevails in the academic literature. This strong focus on manufacturing overlooks the range of service and consultancy activities involved, such as engineering, construction, installation, and service and maintenance (Kuntze and Moerenhout, 2013). While such activities could play an equally important role in fostering local industrial development, LCRs and research in this field have generally devoted limited attention to this issue. In many cases, service functions, such as project development and engineering, procurement and construction (EPC), are high-value added activities (Matsuo and Schmidt, 2019). Hence a broadening of the perspective to include service-related activities could provide a more accurate picture of the effects of LCRs on local industrial development (OECD, 2015).

# 7. CONCLUSION

The current paper set out to analyse the literature on the role of LCRs adopted under RE auction schemes in promoting local industrial development in developing countries. It focuses specifically on the establishment of the local manufacturing of onshore wind power and solar PV components in South Africa, Brazil, India and China, as these countries have been covered most extensively in the literature. Hence, existing knowledge on the effectiveness of LCRs in promoting local industrial development is based on a relatively limited sample of relatively large developing economies. Expanding the geographical scope of research in this field might therefore be considered in order to ensure comprehensiveness.

Concerning the main effects of the LCRs on local industrial development identified in the literature, the paper provides a number of interesting findings. Generally, the literature has ascribed importance to the role of LCRs in promoting local industrial development through the localisation of component production. Two opposing cases can be highlighted: the limited versus the high effectiveness of the LCRs in promoting the localisation of wind turbine component manufacturing in South Africa and China respectively. Furthermore, while the localisation of wind turbine manufacturing in South Africa and Brazil has been confined mainly to the low value-added components, such as towers, domestic component production in China has included higher value-added items, such as nacelle components. The LCRs for solar PV have generally been described as being effective across the four countries analysed here, albeit mainly in terms of module assembly as opposed to the production of wafers and cells. Finally, the paper points to a need to develop a common assessment framework to analyse the effectiveness of LCRs more systematically.

Concerning the key explanations provided in the literature accounting for variation in the effectiveness of LCRs across countries and technologies, a number of pertinent observations can be mentioned. We find that a highly varied picture emerged both within and between the countries and technologies analysed concerning the factors either encouraging or limiting the effectiveness of the LCRs. While the four main determining factors provided a useful heuristic analytical device, we identify a need to pursue research aimed at analysing the relative importance of the individual factors, preferably at the level of individual companies.

Overall, it can be concluded that the use of LCRs as part of RE auction schemes in larger developing countries appears to be conducive to promoting local industrial development. However, in themselves LCRs should not be seen as a panacea since their effectiveness depends critically on a range of determining factors. In turn, these factors are influenced fundamentally by various additional policies, such as market size and industrial capabilities, which are closely linked to energy policies and science and technology policies respectively. As such, LCRs are a measure falling in between the main sectors and policy areas of energy and industry. Seen from an economic point of view, energy policy-makers will be inclined to ensure the lowest possible price of the electricity produced, which may necessitate imports of ever-cheaper components from the global market at the expense of locally produced components priced comparably higher (Matsuo and Schmidt, 2019). In contrast, seen from the perspective of the industrial policy-maker, RE auction schemes may be seen as an opportunity to promote industrial development in key sectors of interest, thus favouring a strong focus on the localisation of production activities. As such, auction schemes have many objectives, between which there are clear trade-offs that are not easily resolved (Hochstetler and Kostka, 2015; Bayer et al., 2018).

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# ENDNOTES

1. *The Chinese auction scheme involved annual bidding rounds with technology-specific auctioned volumes, which, for individual wind-power projects, ranged between 100 MW and 300 MW (IRENA, 2013). The auctioned volumes were project-specific and involved competitive bidding for particular project sites selected by the government (IRENA, 2015).*

2. *Indeed, under the LCRs, the leading foreign technology suppliers were willing to localize production and engage in partnerships with Chinese companies in order to gain access to this large market. Since this involved a risk for the foreign companies of the copying and loss of intellectual property to local firms, this situation came to be known as 'trading technology for market access' (Hansen and Lema, 2019).*

3. *Held (2017) provided the following example as an illustration. If a project developer decided to assemble only the module in Brazil (thus complying with the 60% requirement) while sourcing all the other components from abroad, funding would be restricted to 42% of the investment costs (60% x 70% = 42%). If a project developer decided to produce also the cells and the glass in Brazil (60% + 30% + 10% = 100%), funding would cover 70% of the total project costs (100% x 70%).*

4. *Interestingly, while the domestic steel industry and related engineering in South Africa is generally known to be well developed (see e.g. Bam and De Bruyne, 2018), such insights have not been taken into consideration in the literature.*

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