Received: 12 February 2024 | Revised: 11 December 2024 | Accepted: 18 December 2024

DOI: 10.1111/psj.12590

PSJ POLICY STUDIES JOURNAL

RESEARCH NOTE

Does policy design matter for the effectiveness of local content requirements? A qualitative comparative analysis of renewable energy value chains

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Funding information
Bundesministerium für Bildung und Forschung; Brandenburger Staatsministerium für Wissenschaft, Forschung und Kultur

Abstract

Green industrial policies aim to create local value from renewable energy (RE) technologies. One policy instrument includes local content requirements (LCR), which prescribe a minimum share of locally manufactured inputs for investments in RE. However, the policy effectiveness of LCR differs. While they fostered local industries with rising exports in some countries, they were less successful in others. This paper analyses whether differences in LCR's effectiveness can be explained by policy design elements and the interaction with political economy factors. The paper contributes novel insights on necessary and sufficient conditions for LCR policies' effectiveness in wind and solar energy value chains. It is based on the first qualitative comparative analysis on the topic, covering 27 cases between 1995 and 2017. The analysis reveals that LCR are only effective in fostering green domestic industries if the enforced share of locally manufactured components is not too high, or when applied in countries with related industries. Furthermore, the paper outlines combinations of policy design elements that are sufficient for policy effectiveness even in challenging political economy contexts. The insights on context-specific policy designs for LCR effectiveness are relevant for policy design theory as well as for policymakers and industry experts.

KEYWORDS

comparative research, energy policy, green industrial policy, policy design, qualitative comparative analysis, sustainable development

INTRODUCTION

Industrial policy is experiencing a recent revival, particularly in the form of green industrial policies. China has pioneered this approach, and many countries are now adopting green industrial policies to foster a green transition and local economic development. Local content requirements (LCR) are one prominent industrial policy that experiences a recent revival in the renewable energy (RE) sector. LCR prescribe a minimum share of locally manufactured components to protect domestic industries in a phase of development and learning until they have reached enough scale to compete internationally (Kuntze & Moerenhout, 2012). A prominent example is the United States' "Inflation Reduction Act" (Eicke, 2023). It provides USD 370 billion for green subsidies tied to LCR to boost technology leadership and domestic jobs creation (Department of Energy, 2023). However, LCR remain controversial, as they often contravene World Trade Organization rules (Wu & Salzman, 2013) and have shown mixed effectiveness across countries, supporting export growth in some (e.g., China and Spain) but not in others (e.g., India and Italy) (Bazilian et al., 2020; Scheifele et al., 2022).

Taking this empirical puzzle as a starting point, this paper investigates how different policy design elements affect the effectiveness of LCR in the RE sector. Using qualitative comparative analysis (QCA) the paper systematically compares 27 cases from 1995 to 2017. By integrating policy design theory with empirical studies on LCR, the paper identifies combinations of policy elements that lead to effectiveness even in challenging contexts. The findings suggest that LCR are effective only when not overly restrictive or when applied in countries with related industries, but no single criterion is sufficient on its own. The results highlight that effective policy designs vary significantly with the political economy context, underscoring the importance of complementary policy mixes and non-restrictive designs in less favorable settings.

The paper contributes to a refinement of policy design theory in three regards. First, it combines various datasets to present new empirical evidence on the under-researched interactions between policy design elements and contextual factors, taking the case of LCR in the RE sector as an example. Second, the paper exemplifies that there is no single optimal policy design. Instead, there are multiple pathways to policy effectiveness depending on the political economy context. Third, the findings emphasize different mechanisms behind policy effectiveness and policy ineffectiveness. These insights can guide future research and help policymakers to design more effective green industrial policies.

The paper is structured as follows. Literature Review and Framework section reviews the literature on policy design and LCR, Methodology section presents the methodological approach and data, Results section discusses the findings, Discussion section explores their relevance for policy design and outlines entry points for further research, and Conclusion section concludes.

LITERATURE REVIEW AND FRAMEWORK

Smart policy designs for policy effectiveness

How to design effective policies is a key question of public policy scholarship. Policy design studies take "the effort to more or less systematically develop efficient and effective policies through the application of knowledge about policy means gained from experience, and reason, to the development and adoption of courses of action that are likely to succeed in attaining their desired goals or aims" (Howlett & Lejano, 2013). While policy design scholars examine policy design as a process and as content (Siddiki & Curley, 2022), this paper focuses on how the latter relates to policy effectiveness—the extent to which a policy achieves its stated goals (Bali et al., 2019).

Policy design theorists propose several principles to enhance policy effectiveness. Howlett and Rayner (2007) emphasize the principles of coherence of policy goals, consistency in combined policy instruments, and congruence of policy targets and suggest that these principles are broadly applicable

across policy fields and jurisdictions. Gunningham and Sinclair (1998) provide a detailed discussion of policy design principles for 'smart regulation' in the field of environmental policy. They argue for less interventionist policy designs due to lower costs and higher political acceptance. If required, policy responses could escalate in sequence. Furthermore, the authors promote policy mixes of multiple, consistent, and complementary instruments because single instruments are often inflexible and inefficient. However, they also advocate against "regulatory overload" and aim for parsimony.

Despite rich theoretical debates, there is a recognized lack of empirical, comparative research on the relationship between policy design principles and policy effectiveness (Capano & Howlett, 2020; Fernández-i-Marín et al., 2021; Siddiki & Curley, 2022; van Geet et al., 2021). First empirical studies suggest that the relationship might be more complex: certain principles are not always necessary for effectiveness and incoherent policy designs prove more efficient in some contexts (van Geet et al., 2021). As the debates on the role of context in policy design are just evolving, scholars call for more empirical research on how these principles operate in different settings (Gunningham & Holley, 2016; Lejano & Shankar, 2013; Schleifer & Fransen, 2022; Van Gossum et al., 2010). Addressing this gap, this study examines the relationship between selected policy instruments and effectiveness across varying political economy contexts, focusing on LCR.

Policy design elements of LCR in the renewable energy sector

LCR are a key industrial policy tool aimed at fostering competitive domestic industries in RE, particularly wind and solar (Kuntze & Moerenhout, 2012). While LCR are often associated with export growth, their objectives can also include import substitution, strengthening domestic supply chains, and reducing dependence on foreign technology. Policy effectiveness in this context generally refers to achieving these specific targets; this study focuses specifically on export growth of domestically produced RE technology components (Scheifele et al., 2022).

Empirical studies on LCR are limited and present mixed evidence regarding their effectiveness (Bazilian et al., 2020; Kuntze & Moerenhout, 2012; Veloso, 2001). LCR are seen as a key enabler of the Chinese rise as a global wind technology exporter and supported the build-up of competitive industries in Spain, Morocco, or Uruguay, but have not achieved those goals for India, Italy, or Argentina (Scheifele et al., 2022). Although previous case-study-driven research mentions the importance of policy design for LCR effectiveness, this stream of research has largely abstained from engaging with policy design theories to explain this empirical puzzle (Hansen et al., 2020; Kuntze & Moerenhout, 2012; Matsuo & Schmidt, 2019; Scheifele et al., 2022; Zhang & Gallagher, 2016). Consequently, the impact of policy design principles on effectiveness has not been systematically evaluated across a broader range of countries.

This study argues that the policy design theory offers valuable insights into the mixed results of LCR effectiveness by emphasizing coherence, consistency, and context in policy design. Conversely, the empirical analysis of LCR in the RE sector offers a basis for further theoretical refinement by revealing the complexities and diverse pathways through which different policy elements and contextual factors interact to shape policy effectiveness.

Based on a review of policy design theory and empirical studies, this study identifies three policy design elements—restriction level, financial incentives, and RE targets—and two contextual factors—favorable market and investment conditions and economic complexity—as being particularly relevant to LCR effectiveness. These elements were chosen for their prominence in both literatures and their directly described impact on LCR outcomes. Other factors like inclusiveness, transparency, or regime type, while potentially important, were excluded because they were not specifically tied to the mechanisms through which LCR policies operate in the RE sector. The selected factors are detailed in the following paragraphs and summarized in Table 1.

High shares of prescribed local content are often described as a factor limiting policy effectiveness, in line with policy design theory's preference for less interventionist approaches (Gunningham

TABLE 1 Directional expectations for the relation of policy design elements, contextual political economy factors, and LCR (in-) effectiveness.

	Condition	Ceteris paribus, the condition leads to LCR effectiveness when…	Ceteris paribus, the condition renders LCR ineffective when…
Policy design elements	C1 Restrictive LCR	Absent	Present
	C2 Policy mix with financial incentives	Present	No expectation
	C3 Policy mix with renewable energy target	Present	No expectation
Political economy context	C4 Favorable market and investment condition	Present	Absent
	C5 High economic complexity	Present	Absent

& Sinclair, 1998). Empirical studies suggest that overly stringent LCR can deter investment or lead to regulatory circumvention, particularly when local industries cannot produce goods at competitive prices or quality levels (e.g., Argentina) (Kuntze & Moerenhout, 2012; Lewis & Wiser, 2007; Matsuo & Schmidt, 2019; Münch & Scheifele, 2023; Scheifele et al., 2022). In contrast, a non-restrictive policy design at the time of introduction might increase LCR effectiveness. A less restrictive policy design at the outset, with stepwise increases as local production capacity grows, has been effective in China (Kuntze & Moerenhout, 2012; Matsuo & Schmidt, 2019; Münch & Scheifele, 2023; Scheifele et al., 2022) (Gunningham & Sinclair, 1998).

Consistent policy mixes are also expected to increase policy effectiveness (Gunningham & Sinclair, 1998). Münch and Scheifele (2023) argue that the demand shock from the introduction of LCR in India has been too small to enable domestic manufacturers to catch up with global competitors, highlighting the need for additional policy tools to increase investments. LCR are often embedded in a mix of RE policy instruments. Out of 19 countries with LCR in this study, 12 set specific targets for the RE sector and nine provide financial incentives (Scheifele et al., 2022).

Financial incentives, like grants or subsidies, can complement LCR by attracting international investment, which facilitates local learning and competitiveness in a phase of scaling up local RE industries (Hansen et al., 2020; Kuntze & Moerenhout, 2012; Münch & Scheifele, 2023; Rodrik, 2008).

Similarly, RE targets can signal future demand and enhance planning security. If credible, this may attract international investments that can facilitate learning and competitiveness in industries. In turn, the lack of planning security hindered the success of LCR in Brazil (Bazilian et al., 2020; Kuntze & Moerenhout, 2013).

Additionally, contextual factors of a country's political economy might affect the relation between policy design elements and LCR effectiveness (Howlett, 2018; van Geet et al., 2021).

Market and investment conditions are reflected in differing costs of capital for new investments in RE industries. Low capital costs encourage international investments and facilitate skill and technology transfer critical to LCR success, especially in countries like China (Hansen et al., 2020; Kuntze & Moerenhout, 2012; Lewis & Wiser, 2007; Matsuo & Schmidt, 2019; Scheifele et al., 2022; Zhang & Gallagher, 2016).

The success of green industrial policies such as LCR has been often connected to economic complexity, which refers to a country's productive capabilities. High economic complexity indicates relevant technological skills in the local workforce, which increases the likelihood of upgrading value chains and for economic growth (Eicke & De Blasio, 2022; Eicke & Weko, 2022; Hansen et al., 2020; Kuntze & Moerenhout, 2012; Lewis & Wiser, 2007; Malhotra & Schmidt, 2020; Matsuo & Schmidt, 2019; Münch & Scheifele, 2023; Scheifele et al., 2022).

Policy design theorists and empirical studies on LCR have mostly discussed policy design principles in isolation and have mostly abstained from characterizing how those design elements relate to policy

effectiveness beyond being favorable or not. Furthermore, most studies focus on policy effectiveness, while the reasons for policy ineffectiveness, which might differ, remain largely unexplored.

This study contributes new empirical evidence and theoretical insights on the relation between these conditions and policy (in-) effectiveness and argues that the method of QCA provides the basis for further theoretical refinement. QCA specifies whether certain policy design elements and contextual factors are necessary or sufficient for policy effectiveness, providing a nuanced understanding of how different conditions combine for an outcome. Another advantage of QCA is that it accounts for three elements of causal complexity: First, *equifinality*, that is, it may identify various mutually non-exclusive explanations for policy effectiveness; second, *conjunctural causation* accounts for the phenomenon that sometimes only combinations of conditions might lead to policy effectiveness; third, *causal asymmetry* describes that the cause of policy effectiveness is not the inverse of the cause of the policy ineffectiveness, requiring separate analysis (Misangyi et al., 2017; Thomann, 2020).

METHODOLOGY

Method

This study uses fuzzy-set qualitative comparative analysis (fsQCA) (Ragin, 1987, 2000; Ragin & Fiss, 2008), a method increasingly used in social science to examine policy effectiveness (Rihoux et al., 2011; Thomann, 2020). QCA is well-suited for small to medium-sized samples, where traditional statistical methods may be unable to detect meaningful patterns (Ragin, 2000). Unlike regression analysis, which isolates the effects of individual variables, QCA focuses on how combinations of conditions lead to specific outcomes, allowing for a nuanced understanding of complex, real-world settings (Meuer & Rupietta, 2017; Rihoux & Marx, 2013; Vis, 2012). It also accommodates non-linear relationships and multiple pathways to the same outcome (equifinality) without strict assumptions about linearity or multicollinearity (Fiss, 2007; Marx et al., 2014; Meuer & Rupietta, 2017; Vis, 2012).

The studied sample includes 27 cases of LCR introduction in the wind or solar sector across 124 countries from 1995 to 2017, based on the most comprehensive dataset by Scheifele et al. (2022). Due to data limitations, more recent developments, such as Malaysia's emergence as a solar exporter in recent years, are not covered (Ratan, 2023). Cases are comparable due to their shared goal of fostering domestic industries through RE policies, despite differences in policy design and contexts. Cluster analysis was used to ensure comparability despite technological differences (Malhotra et al., 2019; Malhotra & Schmidt, 2020), and to account for early (1995–2005) versus later (2006–2017) market phases in which both technologies and markets matured (Matsuo et al., 2024) (see Annex—Tables S10 and S11).

FsQCA uses calibration to assign fuzzy-set membership scores (ranging from 0 to 1)[1] that indicate the degree to which cases fulfill the studied conditions (Ragin, 2009; Schneider & Wagemann, 2010). The scores are derived using direct calibration, based on three empirical thresholds guided by the literature and theoretical reasoning, with no cases set at the cross-over point of 0.5 (Ragin, 2009). Details on calibration and data sources are provided in Data section.

The calibrated data allow for the analysis of necessary and sufficient conditions for both policy effectiveness and ineffectiveness. Necessary conditions are always present when policy effectiveness is reached. A sufficient condition implies that policy effectiveness is always reached when the respective condition is present. Recognizing that many social phenomena may result from asymmetric causal processes and conditions, it is standard of good practice in QCA to analyze the outcome and its negation separately, which can uncover insights about negative cases, enriching the overall interpretation of findings (Ragin, 2004; Schneider & Wagemann, 2010).

The analysis of sufficiency uses a truth table, summarizing all possible combinations of conditions to identify which combinations of conditions are consistently associated with the outcome (see Annex—Tables S5 and S6). Based on Boolean Algebra, sufficiency conditions are derived in a process of "logical minimization," in which alternative combinations of conditions are compared and combined

if configurations leading to the same outcome differ by only one condition to derive parsimonious solutions.

Three solution types—conservative, intermediate, and parsimonious—are derived from the truth table. The conservative solution is only based on empirically cases and does not include theoretically possible configurations of conditions that lack empirical observations (remainders) in the process of logical minimization. The intermediate and parsimonious solutions include some of these remainders: the intermediate solution uses only remainders in line with the theoretical assumptions (see Table 1), the parsimonious solution uses all remainders. Following Ragin and Fiss (2008), conditions that are present in both the intermediate and the parsimonious solution indicate stronger evidence and can be considered core conditions; contributory or peripheral conditions are only depicted in the intermediate solution. In this study, the intermediate solution is taken as the basis for interpretation as it balances parsimony and complexity by incorporating theoretical and substantive knowledge to avoid overly simplistic models while still providing a clear and meaningful understanding of the causal pathways and is commonly chosen for interpretation (Duşa, 2022; Ide & Mello, 2022; Mello, 2021). Recognizing ongoing methodological debates on the solution type best suited for interpretation, results for all three solution types are presented in the Annex (Tables S7 and S8) (Baumgartner & Thiem, 2020; Duşa, 2022; Haesebrouck & Thomann, 2021; Schneider & Wagemann, 2013).

The analysis is conducted in R (version 4.4.0) using the QCA (version 3.22) (Duşa, 2018) and SetMethods packages (version 4.0) (Oana & Schneider, 2018).

Data

The following section presents the operationalization of conditions and the data sources and details the process of calibration guided by the literature and theoretical reasoning. The raw and calibrated dataset, cross-correlation table, and sensitivity ranges for calibration decisions are available in the Annex (Tables S1, S2, and S9).

LCR policy effectiveness is proxied through solar and wind technology exports in current USD, following Probst et al. (2020) and Scheifele et al. (2022), based on the compilation of exports of 23 relevant solar energy technology components and 80 wind energy technology components by Scheifele et al. (2022). This captures the extent to which LCR have contributed to the growth of internationally competitive industries capable of exporting RE technology components. While this metric does not account for LCR-induced growth in domestic production that is not exported, as in the case of India (Probst et al., 2020) export data remain the most comprehensive and comparable proxy available at a global scale. Other potential measures of LCR effectiveness, such as manufacturing capacity (Bazilian et al., 2020; Matsuo & Schmidt, 2019), job creation (Lewis & Wiser, 2007), or firm-level indicators like patents and revenues (Münch & Scheifele, 2023) are valuable but lack consistent, yearly, and globally comparable data. Some studies have used alternative measures to assess LCR outcomes, but they still reference export performance as an indicator of success (Baker & Sovacool, 2017; Johnson, 2016; Kuntze & Moerenhout, 2012; Münch & Scheifele, 2023). Export growth is assessed 4 years after LCR introduction to standardize temporal variation (Fischer & Maggetti, 2017) and to account for the time needed to build industrial capacity (Hansen et al., 2020). The calibration thresholds are based on theoretical reasoning due to the lack of explicit thresholds in the literature. The crossover point, representing neither growth nor shrinkage in exports, was set at 100%, with full membership set at a 20% increase in exports (120%) and full non-membership at a 10% decrease (90%). Sensitivity analysis shows robustness across a broad range of varying calibration points (see Annex—Table S9), with 56% of cases scoring above 0.5.

Restrictive LCR are coded based on data provided by Scheifele et al. (2022). The required local content shares vary between 15% (in Ukraine) and 100% (in Malaysia). The calibration was guided by theoretical considerations due to the lack of explicit thresholds in the literature (Kuntze & Moerenhout, 2013). The threshold for full membership in the set of restrictive policies was set at an initial threshold above 59%, in line with Bazilian et al. (2020) describing local content shares of 60% and 70% as relatively high. The

crossover point is set at 49%, with lower thresholds for full exclusion below 39%. Sensitivity analysis confirms these thresholds are robust within a reasonable range (see Annex—Table S9), with 37% of cases scoring above 0.5.

Financial incentives and RE targets are coded as binary conditions based on their presence or absence, using data from the Bloomberg New Energy Finance Renewable Energy Policy Dataset (BNEF, 2020). Countries with these policies are coded with 1, others with 0.

Market and investment conditions are measured by the weighted average costs for capital (WACC) for RE projects, estimated by IRENA (2023). Following IRENA (2023), countries with a WACC below 5.0% are fully included in the set of favorable market conditions, with a crossover point at 5.5% and full exclusion above 7.5%. Sensitivity analysis indicates robustness across different settings (see Annex—Table S9), with 44% of cases scoring above 0.5.

Economic complexity is measured based on the average economic complexity index over the considered timespan (OEC, 2023). This indicator has been used in previous studies on LCR (Scheifele et al., 2022). Following the thresholds provided by Hausmann (2023), countries with an ECI above 1.25 are fully included in the set of highly complex economies, with thresholds for partial membership and exclusion adjusted accordingly. Sensitivity analysis confirms robustness, with 52% of cases scoring above 0.5 (see Annex—Table S9).

RESULTS

The analysis shows that no single policy design element or contextual factor is necessary or sufficient for LCR policy effectiveness. For complex outcomes, single conditions are seldom necessary or sufficient. Instead, necessity and sufficiency often arise from the combination of conditions (Duşa, 2018). Accordingly, the findings highlight multiple effective, context-dependent policy designs. The following sections present separate analyses of necessary and sufficient conditions for both policy effectiveness and ineffectiveness.

Analysis of necessity

The analysis finds that either a non-restrictive LCR policy design or high economic complexity is necessary for LCR effectiveness (see Annex—Table S3). An XY-Plot confirms the relation of necessity, showing no cases where one of these conditions is present without achieving effectiveness (see Annex—Figure S1).

These conditions meet the established thresholds for consistency[2] (0.9) and coverage[3] (0.5) for necessary conditions (Mello & Ragin, 2019) although the relevance of necessity (RoN) of 0.44 is slightly below the recommended threshold of 0.5 indicating potential triviality. However, the triviality hypothesis is rejected, as some cases lack both conditions and the outcome (see Annex—Figure S1) (Goertz 2006). *Furthermore, the finding* has theoretically grounded explanatory relevance (Mello & Ragin, 2019), as they align with existing literature. A non-restrictive policy design is considered to be especially important in countries with limited technological skills, while increasing levels of economic complexity might allow for a more restrictive LCR policy design (Kuntze & Moerenhout, 2012; Matsuo & Schmidt, 2019; Münch & Scheifele, 2023; Scheifele et al., 2022).

No condition is necessary for policy ineffectiveness (see Annex—Table S4).

Analysis of sufficiency

The analysis identifies four solution paths, each combining several conditions sufficient for the outcome. Table 2 illustrates these paths, following the notation introduced by Ragin and Fiss for

TABLE 2 Sufficient conjunctural patterns of policy design elements and contextual factors for LCR policy effectiveness.

	Solution			
	1	**2**	**3**	**4**
Policy design				
High restrictiveness		⊗	⊗	⊗
Policy mix—financial incentives	⊗	⊗		●
Policy mix–RE target	⊗	●	●	⊗
Political economy				
Favorable market and investment conditions	●		⬤	
High economic complexity	●			⬤
Consistency	1.0	0.798	0.779	0.972
Raw coverage	0.285	0.158	0.179	0.089
Unique coverage	0.285	0.111	0.132	0.089
Overall solution consistency	**0.901**			
Overall solution coverage	**0.663**			
Cases	Wind: Canada, China, Spain Solar: Canada, France	Wind: Morocco Solar: Morocco	Solar: South Africa, Wind: Uruguay	Wind: Ukraine Solar: Ukraine

Note: ⬤/● = core/contributory condition present; ⊗/⊗ = core/contributory condition absent; .blank fields = not relevant.

the combined representation of the intermediate and parsimonious solution (Fiss, 2011; Furnari et al., 2021; Ragin & Fiss, 2008). The mapping of these solution paths confirmed that policy effectiveness is reached, whenever these combinations of conditions are present (see Annex—Figures S2–S5). Cluster analysis confirmed the relevance of these solution paths both for the wind and solar sector.

Solution path 1 describes that LCR policy effectiveness can be fostered by favorable market and investment conditions that enable the attraction of international investors and an existing high economic complexity. These conditions enabled the successful build-up of domestic RE industries in Canada, China, Spain, and France. In such a supportive political economy context, policy mixes are not needed and the policy design of LCR restrictiveness is irrelevant; even restrictive requirements for LCR could be fulfilled. For example, favorable investment conditions and prior technological knowledge supported growth in the domestic wind energy industry in Spain despite the introduction of a restrictive policy design, which required 70% of local content (Kuntze & Moerenhout, 2013). This is the only solution path that covered cases in an early phase of technological and market development (1995–2005) and in a later phase in which both markets and technologies matured (2006–2017). The other solution paths only cover cases in the later phase.

In contrast, solution paths 2, 3, and 4 illustrate how LCR effectiveness is obtained in countries with more challenging political economy contexts—without favorable investment conditions in the case of Ukraine (path 4), without high economic complexity in South Africa and Uruguay (path 3) or with none of the two in Morocco (path 2). A core element in these solution paths is that LCR are designed in a non-restrictive way, which allows the gradual build-up of domestic production capacities. Furthermore, all these paths include policy mixes, Uruguay and South Africa with financial incentives and targets, and Ukraine with financial incentives but without targets. These policy mixes additionally facilitated the attraction of international investments.

A second analysis is conducted to determine sufficient conditions for *in*effective LCR policies. In all cases covered by the solution, the LCR policy design is restrictive, reaching up to 100% in the case of Malaysia. This suggests that a restrictive design of LCR may hinder the effectiveness of LCR, despite additional supportive policies, for example, financial incentives in Brazil, Malaysia, India, and Argentina (solution 1 and 2); or RE targets in Croatia, Greece, and Italy (solution path 3). The third solution path hinders policy effectiveness even in favorable investment contexts. In solution path 2, both, favorable investment conditions and high economic complexity are lacking and hinder policy effectiveness, whereas both elements are irrelevant in solution path 1 (Table 3).

The presented solution coverage is 0.66 and 0.58, respectively, indicating that some cases are not explained by these solution paths. All results are robust, with sensitivity ranges calculated following Oana and Schneider (2024) (Annex—Table S9).

DISCUSSION

The findings support the hypothesis that LCR policy design matters for policy effectiveness. The paper adds new, empirical insights of theoretical relevance into the relationship between policy design elements, political economy contexts, and policy effectiveness by specifying how these conditions interact in relations of necessity and sufficiency. Three examples illustrate how this specification adds to a refinement of policy design theory:

First, while policy design scholars advocate for low interventionist policies and gradual increases in intervention (Doern & Wilson, 1974; Gunningham & Sinclair, 1998; Howlett, 2018) in line with empirical studies on LCR (Hansen et al., 2020; Kuntze & Moerenhout, 2012; Scheifele et al., 2022), this study specifies that a non-restrictive LCR policy is crucial for effectiveness in challenging political economy contexts but less relevant in supportive ones. Thus, either a non-restrictive policy design or high economic complexity is necessary for LCR effectiveness.

TABLE 3 Sufficient conjunctural patterns of policy design elements and contextual factors for the outcome of LCR policy ineffectiveness.

	Solution		
	1	**2**	**3**
Policy design			
High restrictiveness	●	•	●
Policy mix—financial incentives	●	•	⊗
Policy mix—RE target	⊗		●
Political economy			
Favorable market and investment conditions		⊗	●
High economic complexity		⊗	
Consistency	0.994	1000	0.857
Raw coverage	0.161	0.186	0.244
Unique coverage	0.147	0.172	0.244
Overall solution consistency	**0.932**		
Overall solution coverage	**0.577**		
Cases	Wind: Brazil Solar: Malaysia	Wind: Argentina Solar: Argentina, India	Wind: Croatia Solar: Greece, Italy

Note: ●/• = core/contributory condition present; ⊗/⊗ = core/contributory condition absent; . = not relevant.

Second, although a preference for parsimonious policy designs exists (Howlett, 2018; Knudson, 2009; Tinbergen, 1952) consistent policy mixes are also seen as beneficial in policy design theory (Gunningham & Sinclair, 1998; Howlett, 2018). This study adds nuance by showing that a simple policy design suffices in supportive contexts, but in less favorable contexts, effective LCR requires policy mixes with financial incentives or RE targets. Additionally, the study reveals that in early market phases, combined with supportive contexts are effective, while mature markets required more diverse policy mixes, supporting the "green windows of opportunity" concept (Matsuo et al., 2024). These findings contribute to an emerging debate on the role of context in policy design theory, and call for more empirical, context-specific research (Gunningham & Holley, 2016; Lejano & Shankar, 2013; Schleifer & Fransen, 2022; Van Gossum et al., 2010).

Third, policy design theory tends to focus on principles for policy effectiveness. This paper illustrates that the absence of these principles does not automatically result in ineffective policies. Different mechanisms drive policy effectiveness and ineffectiveness. For example, a restrictive LCR policy is central to all paths for policy ineffectiveness, while political economy context is less relevant. Conversely, a supportive context alone can suffice for effectiveness, regardless of LCR restrictiveness. These findings call for further research on the mechanisms behind the separate phenomena of policy effectiveness and policy ineffectiveness in policy design research.

The paper demonstrates that QCA can substantially contribute to a refinement of policy design theory by accounting for causal complexity—equifinality, conjunctural causation, and causal asymmetry. Combining QCA with case-oriented methods like process tracing seems promising for further research, and could yield further, more granular insights into the causal mechanisms of how policy design elements interact with political economy contexts for policy effectiveness. Such approaches could also identify additional factors influencing these interactions, especially for a further investigation of cases that are not covered by the solution paths in this analysis, such as LCR in Jordan's solar sector, Russia's

wind sector, and Turkey's solar sector. Furthermore, future research on LCR policy effectiveness would greatly benefit from improvements in the availability of comparable data on more granular policy design features, including technology component requirements, or requirements on technology transfer and local learning.

CONCLUSION

These findings are relevant for policymakers in the RE sector, in a time in which green industrial policies increasingly gain political momentum. The paper shows that the effectiveness of LCR in the RE sector strongly depends on policy design and the country's political economy. Accordingly, the paper outlines combinations of policy design elements that can lead to policy effectiveness even in unfavorable political economy contexts. LCR have only been effective when a non-restrictive LCR policy design is chosen or in a country with high economic complexity. While policy design elements are less relevant in favorable political economy contexts, a non-restrictive LCR policy design and complementary policy mixes are of key importance for policy effectiveness in countries without favorable market and investment conditions or high economic complexity.

These findings illustrate how a smart design of green industrial policies can contribute to the development of competitive export industries even in countries with non-favorable market and investment conditions. This contributes to vivid political and academic debates on the distribution of gains and losses from the global energy transition among countries worldwide (Eicke et al., 2019; Eicke & De Blasio, 2022; Goldthau et al., 2020; Overland et al., 2019).

The paper contributes to a refinement of policy design theory in three regards. First, it presents new empirical evidence on the under-researched interactions between policy design elements and contextual factors using the example of LCR in the RE sector. Second, the paper challenges the idea of universally applicable policy design principles by showing that effective policy designs depend on the political economy context. Third, the findings illustrate the importance of accounting for different modes of action resulting in policy effectiveness and policy ineffectiveness. These insights might serve as entry points for future research on interactions between policy design, political economy contexts, and policy effectiveness in the RE sector and beyond.

ACKNOWLEDGMENTS

The author is thankful for valuable feedback on previous versions of the paper at the European Conference for Political Science (ECPR) as well as at the International QCA Paper Development Workshop 2023. Open Access funding enabled and organized by Projekt DEAL.

FUNDING INFORMATION

This research is funded by the Research Institute for Sustainability (RIFS), Helmholtz Centre Potsdam, Germany.

CONFLICT OF INTEREST STATEMENT

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

DATA AVAILABILITY STATEMENT

The data used in this analysis is included in the Annex.

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Endnotes

[1] A continuous calibration of data is chosen to preserve the rich information in the data whenever possible; however, two conditions (policy mix with financial incentives and policy mix with renewable energy target) are coded in a crisp way due to the binary raw data structure.

[2] Consistency measures indicate how close the empirical relationship between single or combined conditions and the outcome comes to set-theoretic necessity or sufficiency.

[3] Coverage measures indicate the empirical relevance of single or combined conditions for explaining the outcome.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Eicke, Laima. 2025. "Does Policy Design Matter For the Effectiveness of Local Content Requirements? A Qualitative Comparative Analysis of Renewable Energy Value Chains." *Policy Studies Journal* 00(0): 1–14. https://doi.org/10.1111/psj.12590.