Developing local industries and global value chains: The case of offshore wind

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ABSTRACT

Renewable energy sectors are becoming increasingly globalized with lead firms appropriating value on a global scale: This creates challenges for nations seeking to anchor some of the value locally through indigenous industrial development. Since lead firms select their suppliers for a given deployment project, national governments can set incentives for these firms to opt for local suppliers. We use the case of offshore wind in Europe to quantitatively measure the origin of suppliers across three global value chain governance modes: *market, modular* and *relational*. Suppliers can originate from the windfarm country, the lead firm's country or the global market. We test supplier selection across the modes of governance, domestic market size and local content push using a database of over 12,000 supplier contracts. The results indicate that lead firms mostly draw from the global market for market-coordinated segments, while favoring local suppliers under local content regulations. Local lead firms have a higher tendency to source locally for both market and relationally coordinated suppliers. However, local content push reduces the tendency of local lead firms to select local relational suppliers. Therefore, local content requirements seem to be broadly successful to stimulate locally sourced suppliers of the market-coordinated type; on the other hand, our results show that national governments should have local lead firms commission projects without imposing local content regulations to increase the odds that local relational suppliers are selected.

1. Introduction

Europe has committed to becoming carbon-neutral by 2050 in an effort to limit global warming to less than 1.5 °C, which requires significant renewable energy diffusion (European Commission, 2020; IRENA, 2019a). In pursuit of these commitments, opportunities arise for economic value creation and industrial development on a local (national) scale, which can be maximized by stimulating local value chains (IRENA, 2018; Lewis and Wiser 2007). However, the renewable energy sector is becoming increasingly globalized with lead firms – who are often developers – managing their value chains for given projects across the world.[1] Global value chains (GVCs) involve a functionally and geographically fragmented mode of production that is typically coordinated and controlled by lead firms (Elola et al., 2013; Mayer et al., 2017).

This raises questions about how national policy makers can build local industrial capacity to tap into these emerging markets and create benefits for their country (Lacal-Arántegui 2019; MacKinnon et al., 2019; Wieczorek et al., 2015). The stimulation of local industry formation and growth can therefore no longer only rely on conventional national policies but may need to regulate and incentivize globally active companies to privilege local suppliers in their global value chains. Our paper assesses the conditions that influence local supplier selection in the market (project) country when supplier selection is largely in the hands of private developers.

While governments may encourage local supplier selection to stimulate local industry growth, developers in general desire unrestricted sourcing to minimize costs (Kochegura 2017; Munson and Rosenblatt 1997). One strategy governments can employ is a lead market approach, which systematically creates a market for a certain good by creating a protected niche-space, allocating subsidies and establishing diffusion mandates, such as a minimum share of zero emission vehicles. By

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creating demand for a good, the local industry follows and develops the expertise needed to compete, a tactic used in Germany to develop its solar PV industry (Van der Loos et al., 2020a; Nemet, 2009; Peters et al., 2012; Purkus et al., 2017; Quitzow, 2015). Further, countries can turn to local content regulations (LCR), which often set a minimum share of domestic suppliers or value for a given project. If a country has a capable supply base, it may be possible to simply force a developer to select local rather than foreign suppliers; if a country does not have an existing supply base, it may require a developer to train a local workforce or establish local production capacity in exchange for the rights to undertake a project. This may be further stimulated through subsidies or tax incentives.

Nonetheless, developers (lead firms) must select their suppliers according to their needs while factoring in local project conditions such as local content requirements, availability of infrastructure, transportation costs and existing capabilities. Suppliers are therefore chosen either from the country where the project is realized (local industry development) or from the international supply chain (Hanson et al., 2019; Munson and Rosenblatt, 1997; Steen and Hansen, 2018).

The supplier selection process is further complicated by the fact that the developer's relationship with, and their ability to coordinate, suppliers varies across different parts of the value chain. Coordination in global value chains between a developer and its supplier is known as 'mode of governance' and can be grouped into five forms: (1) market, (2) modular, (3) relational, (4) captive, (5) hierarchical (Elola et al., 2013; Gereffi et al., 2005). These five modes of governance are qualified by three parameters: (1) complexity of the transaction, (2) codifiability of the transaction and (3) capability requirements on the side of the supplier. For the developer, these modes represent a gradient of increasing control over its suppliers. The mode of governance associated with each supply chain segment will likely affect whether a supplier is sourced locally or globally.

To unravel the conditions that influence local supplier selection by lead firms, the present paper focuses on offshore wind in Europe, a core renewable that supports Europe's path to a carbon-neutral society (WindEurope, 2019). Realizing the 240–450 gigawatts of offshore wind power by 2050 will require a massive expansion of supply chains, providing plentiful opportunities for industrial development and growth (WindEurope, 2019). Extensive value chains are necessary to build and operate offshore windfarms, and each project involves hundreds of companies originating from different countries (4C Offshore Ltd., 2018; BVG Associates, 2013; Dedecca et al., 2016). As mentioned, the developer is the lead firm for offshore wind projects.

Previous studies stated that power relationships between developers and suppliers in offshore wind are relationally coordinated because high levels of collaboration, cooperation and knowledge exchange, coupled with a high degree of complexity, are required to meet technological and local challenges (see e.g. Binz and Truffer, 2017; Elola et al., 2013; Lema et al., 2011; MacKinnon et al., 2019). Although this might be true at a macrolevel, this research argues that such statements require more nuance. We make a first attempt at breaking down the offshore wind global value chain – as explicitly distinct from its onshore wind counterpart – across the modes of governance that characterize it (Bair and Sturgeon, 2008; Gereffi et al., 2005).

Different segments of the offshore wind supply chain can be categorized by different modes of governance. For example, offshore substations – which collect electricity produced by individual wind turbines for distribution to the national grid – are highly complex and difficult to codify, classifying them in the relational mode of governance. Many vessels, on the other hand, are low in complexity and highly codifiable, leading to a market mode of governance. The suppliers chosen by the developers that construct offshore wind farms therefore fall into different modes of governance (Lacal-Arántegui, 2019; Van der Loos et al., 2020a). Some research has shown that certain suppliers filling the same function – such as 'wind turbines' – may require different modes of governance (Lema et al., 2011); however, for the purpose of this

research and the European geographic delimitation – we consider that all stakeholders from a stakeholder role are coordinated via one specific mode of governance.

Developers may also be inclined to favor suppliers from their home country, a process we introduce as 'developer sourcing'. Empirically, we investigate offshore windfarms in Europe from 2002 to 2019 and employ logistic regressions to investigate patterns of supplier sourcing for different segments of the value chain. It is therefore a significant step towards nuancing the conditions that affect industry growth in the country where the market is – known as local supplier sourcing – when supplier selection is largely in the hands of developers. This leads to the following research question:

Under what conditions do developers support industry growth in the market country through the selection of local suppliers versus selecting suppliers from the global market or from their own country?

Our research proceeds as follows: section two outlines the theoretical notions of spatially complex industrial development and global value chains, which inspires the formulation of our hypotheses. Section three discusses the data and methods. Section four highlights the results with section five analyzing these results according to the hypotheses. Section six underscores the key takeaways and insights into local industry growth and formation, policy implications and reflections on the broader global value chain literature. The conclusion reiterates that developers mostly draw from the global market for the market coordinated segments of the value chain. Local developers have a higher tendency to select local suppliers in general, and particularly within the relationally coordinated segments of the supply chain, except when local content regulations are present. Foreign developers are more likely to draw lower value-added market coordinated suppliers from the windfarm country when there is a push for local content. Local content requirements will therefore most likely benefit indigenous, highly codifiable skill sets. Higher impacts are to be expected if windfarm contracts are delegated to local developers without imposing local content regulations.

2. Theory: the spatial complexity of industrial development and global value chains

2.1. The spatial complexity of industrial development

The birth and growth of a new technology is a complex and multifaceted process (Binz and Truffer, 2017; Musiolik and Markard, 2011; Welie et al., 2019). New technologies compete with both existing technologies, such as renewable energy competing with traditional fossil fuel energy, as well as with other emerging technologies (Bergek et al. 2015; Markard, 2020). Technologies tend to co-evolve with surrounding structures like markets, user practices, infrastructures, social contexts, policy environments and cultural discourses (Van der Loos et al., 2021; Smith, 2000). Although technologies often develop through international networks, many studies are still performed within spatially confined contexts and hence provide only limited insights into the transnational embedding of socio-technical change (Coenen et al., 2012). Such nationally confined studies implicitly assume that the broader global context of a system is represented as an ubiquitous global technological opportunity set, which incorrectly assumes that all interactions have become randomly spread across the globe (Binz et al., 2014; Coenen et al., 2012).

Rather, industrial growth is nested within both dense local actor networks and transnational production networks (Dicken, 2011). In this view, the emergence and growth of new technologies is a complex phenomenon that depends on how processes unfold within and between different geographic scales (Binz and Truffer, 2012; Gallagher, 2014; Grübler, 2003; Van der Loos et al., 2021). How this combination plays out depends on a number of factors, such as the type of industry, the underlying knowledge base of the different activities and varying national characteristics, such as market size, infrastructure and knowledge

networks (Binz and Truffer, 2017; Binz et al., 2014).

Recent literature addresses and conceptualizes the spatial complexities of emerging and rapidly growing sectors (Binz and Truffer, 2017; Binz et al., 2014; Van der Loos et al., 2020a; Sengers and Raven, 2015; Wieczorek et al., 2015). For example, industrial capabilities present in some locations can compensate for absent capabilities elsewhere because the relevant actors, institutions and infrastructure are internationally oriented (Wieczorek et al., 2015).

Countries are confronted with global value chains in their attempt to promote national industrial development. An extensive debate has therefore formed around the best strategies to stimulate industries. A first approach is through a technology-push strategy by investing in research and development to advance key competencies, thereby capitalizing on external markets (Van der Loos et al., 2020a; Negro et al., 2012; Wesseling, 2016). Technological catch-up occurs when countries pursue a technology-push strategy by intentionally activating transnational linkages, knowledge sharing and international outreach (Bento and Fontes, 2015; Gosens et al., 2015; Quitzow, 2015; Wieczorek et al., 2015). In a second instance, countries engage in a lead market (or demand-pull) approach, in which they create confidence and stimulate demand through incentives – such as subsidies – and regulations (e.g., market growth targets) – with the hopes that the industry will follow and generate local employment and income (Choi, 2018; Landini et al., 2020; Nemet, 2009; Peters et al., 2012; Purkus et al., 2017). To address the risk that the benefits of industrial development are not captured in the country, governments sometimes impose local content regulations, typically by requiring a minimum share of local participation on a given project, a phenomenon often seen in developing or catch-up countries (Amsden, 2001; Baker and Sovacool, 2017; Munson and Rosenblatt, 1997). Finally, the combination of a protected domestic market, strict local content regulations and significant investments in a technology-push approach – such as the case of the Chinese wind and solar industries – may result in both industrial formation and market diffusion (Landini et al., 2020; Poulsen and Lema, 2017; Quitzow, 2015). As every country has a unique set of competencies, contexts and institutional structures, their approach to capitalizing on global value chains to expand local industries differs. We henceforth investigate the conditions that influence local industry expansion in light of global value chains.

2.2. Global value chains

Global value chains (GVCs) are defined as "The set of intra-sectoral linkages between firms and other actors through which geographical and organizational reconfiguration of global production is taking place" (Gibbon et al., 2008, 4). GVCs are strongly linked to the global interplay of entrepreneurial activity and market formation processes and nuance a perceived homogenous global opportunity set in which all actors have equal access (Binz et al., 2014; Coenen et al., 2012).

A value chain becomes global when a lead firm takes up the task of selecting a geographically fragmented set of suppliers, which requires a high degree of coordination (Amico et al., 2017; Fagerberg et al., 2018; Humphrey and Schmitz, 2001). Lead firms can be defined as "a dominant party (or sometimes parties) who determine the overall character of the chain, and…become responsible for upgrading activities within individual links and coordinating interaction between the links" (Kaplinsky et al., 2000, 8). They determine whether to develop products in-house or to outsource them by selecting external suppliers (Christopherson and Clark, 2007).

The privilege accorded to lead firms to select their suppliers indicates the presence of a power asymmetry (Christopherson and Clark, 2007; Ponte and Sturgeon, 2014). However, the degree of influence a lead company can exert on its suppliers is variable and can be classified for each value chain segment according to three interdependent parameters that describe the character of the supplier relationship: (1) complexity; (2) codifiability; and (3) capabilities (Gereffi et al., 2005). This leads to

five modes of governance, which are linked to the increasing degree of control a lead company can leverage on its suppliers: (1) *market coordination*, characterized by low complexity transactions, easily codified product specifications and sophisticated supplier competency; (2) *modular coordination*, characterized by the high complexity of transactions, whilst the ability to codify specifications is easy; (3) *relational coordination*, characterized by complex transactions that are not easily codified and highly idiosyncratic relationships with highly competent suppliers, associated with high switching costs to new value chain partners; (4) *captive coordination*, characterized by complex transactions that are easily codified, however the supplier's competence is low, making the supplier dependent upon the lead firm who exerts a high degree of monitoring and intervention; and (5) *hierarchical coordination*, characterized by vertical integration in the case of complex transactions that cannot easily be codified and when the competence of suppliers is low. The five global value chain governance modes are listed in Table 1.

A GVC is characterized by different forms of coordination in various segments, implying that the lead firm-supplier interaction varies (Gibbon et al., 2008). GVC governance thus highlights the organizational forms through which a specific division of labor between lead firms and other agents involved in the conceptualization, production and distribution of goods in global industries is established and managed (Gibbon et al., 2008).

They must therefore select their suppliers, specify contractual arrangements and determine the activities of other firms according to the mode of governance in which different value chain segments are coordinated (Amico et al., 2017; Gereffi et al., 2001; Gibbon et al., 2008). A heterogeneous distribution of power enables more efficient production processes and helps to minimize transaction costs (Wilson and Hearnshaw, 2013).

Suppliers can fall into one of four geographic categories for a given project: (1) *local sourcing*: choosing suppliers from the project country; (2) *developer sourcing*: selecting suppliers from the developer's home country; (3) *local-developer sourcing*: local sourcing of suppliers when the developer also originates from the project country or; (4) *global sourcing*: all other suppliers (Holweg et al., 2010; Yeniyurt et al., 2013).

In determining the mode of governance required for each stakeholder based upon an existing data set of already selected suppliers, we can exclude the 'capabilities' criterion as it can be assumed that, if a supplier has been selected by a developer, it has the capabilities to perform the task. Within the context of Europe, selected suppliers can be considered as capable, whereas limited capabilities and absorptive capacity may be more relevant in global value chain catch-up contexts.

The captive and hierarchical modes of governance require an even higher transaction cost to switch from one supplier to another than value chain segments requiring relational coordination, meaning that the reasons a developer chooses a supplier from the relational, captive or hierarchical mode of governance are likely to show a similar pattern. Further, an existing database of selected suppliers may not have enough detail to distinguish suppliers requiring a captive or hierarchical mode of governance. Hence, the captive and hierarchical modes of governance can be *de facto* excluded when determining the mode of governance for value chain segments.

Every supplier can therefore be categorized into one of three modes of governance – *market, modular* or *relational* – and one of four

Table 1
Key determinants of global value chain governance (Gereffi et al., 2005).

Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of power asymmetry
Market	Low	High	High	Low
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchy	High	Low	Low	High

geographic categories – *local sourcing, developer sourcing, local-developer sourcing* or *global sourcing*. Hence it becomes imperative to understand the underlying mechanisms that affect how developers select their suppliers and how the dominant GVC governance modes explain from where they are sourced.

Empirically, we investigate how GVC governance, local content regulations and market formation affect supplier selection in the offshore wind industry. Our specific hypotheses for offshore wind are described below.

2.3. Hypotheses

Based upon the characteristics of global value chains, modes of governance, market size and local content regulations, we derive a number of hypotheses that we apply to the offshore wind industry to measure the factors that influence local supplier selection. Importantly, the developer of an offshore wind farm is the global value chain lead firm; in the case of offshore wind, the developer is often a utility company – such as Vattenfall, Ørsted or Iberdrola (Elola et al., 2013; GWEC, 2020). Certain supply-chain segments, including wind turbines, may exert some influence over the supply-chain due to their central role and the relatively few participating firms; for example, Siemens-Gamesa and MHI Vestas enjoy an effective duopoly on the European market (Elola et al., 2013; IEA, 2019). However, this followed thirty years of consolidation in the market, meaning that developers used to have more choice in wind turbine selection (The Renewables Consulting Group, 2020). Therefore, the developer is ultimately in control of supply-chain selection.

Local industrial growth occurs when a developer selects a supplier from the country where a project is developed. Standardized parts of the value chain are low in complexity and rest on codified forms of knowledge that are easily transmittable (classifying them in the market mode of governance), therefore making a global sourcing strategy more likely (Dicken, 2011; Elola et al., 2013). Market coordinated supply-chain segments may be relatively simple to establish in a project country and thus have an inherent transportation cost advantage; however, the low complexity and high degree of codifiability mean that suppliers from many countries vie for projects and may be able to outcompete local suppliers through more efficient production practices, automation, lower labor costs, etc. In offshore wind, steel tubulars that make up foundations or standardized crew transfer vessels fit within the market mode of governance (Bair and Sturgeon, 2008).

When both the complexity of the activities in a part of the chain and the ability to codify are high (modularly coordinated), such as wind turbines, the required transaction-specific investments are low and therefore the potential for sufficient coordination of distant activities remains high (Bair and Sturgeon, 2008); a global sourcing strategy is therefore also likely in the segments with a modular governance mode.

Proposition 1. *Global sourcing most likely occurs in the market-coordinated parts of the value chain, followed by the modular parts.*

When activities in a part of the chain are both complex and hard to codify, the underlying knowledge base is tacit in character and requires a relational mode of governance, such as bespoke substation manufacturing or turbine installation (Pietrobelli and Rabellotti, 2011). These activities require close cooperation between a developer and the supplier base, creating high transaction-specific investments. Developers are less likely to adopt a global sourcing model in the case of complex and customized products, processes and services (Amico et al., 2017). Activities that include high transaction-specificity may be more likely to occur between firms that have similar national origins due to the distinctive cultures, practices, histories, trust, institutions and previous collaborations (Dicken, 2011; Henderson et al., 2002). Similarities in backgrounds may facilitate cooperation between business partners, stimulating shared developer-supplier origins over global sourcing (Boschma, 2005; Mackinnon, 2011; Sheth and Sharma, 1997). Indeed,

research has demonstrated that, for example, the Norwegian oil and gas energy giant and offshore wind developer Equinor (formerly Statoil) has a disproportionately strong tendency to favor Norwegian suppliers for its global offshore wind projects (Hanson et al., 2019; Van der Loos et al., 2021; MacKinnon et al., 2019). While cognitive, social, organizational and institutional proximities are likely to have an effect on firm interactions, the offshore wind industry indicates that geographic proximity may play a role in supplier selection (Van der Loos et al., 2021; Steen and Hansen, 2014). Developers may favor suppliers from their own country in segments requiring a relational mode of governance.

Proposition 2. *Relationally coordinated suppliers are more likely to be selected by developers from the same country of origin, followed by the modular and market coordinated parts.*

A market-pull approach is a common strategy countries employ to encourage industry advancement, particularly in the emerging or take-off phases of technological development (Fagerberg, 2010). Through strong industrial strategies, policy makers try to encourage foreign suppliers to establish production facilities in the country where the market is; for example, Siemens-Gamesa established a turbine blade factory in the United Kingdom following a British industrial growth push (Bednarz and Broekel, 2020; Russel, 2016). Moreover, existing local firms with relevant competencies might diversify into the new industry as a result of additional demand (Hansen and Steen, 2015; Van der Loos et al., 2020b; Mäkitie et al., 2018). Thus, the formation of a domestic market can be crucial for initiating the rise or growth of local suppliers and developing sophisticated local industrial capabilities (Dewald and Truffer, 2011; Lewis and Wiser, 2007; Steen, 2016). This leads to the following proposition:

Proposition 3. *(A) Sourcing suppliers from the country where the market is (local sourcing) becomes more likely at a higher installed capacity for all modes of governance. (B) This trend is exacerbated when the project is developed by a local developer.*

Local content requirements constitute an instrument that countries use to shield their economies from foreign competition (Baker and Sovacool, 2017; GWEC, 2020; Veloso and Soto, 2001). The primary objective is to develop local industries, enhance the added value by local activities and increase employment by mandating or strongly encouraging a certain percentage of goods to be provided by local manufacturers or producers (Kuntze and Moerenhout, 2013; Landini et al., 2020; WTI Advisors, 2013). These policies shape industrial upgrading and provide opportunities for local suppliers to compete on local projects (Amsden, 2001; Ponte and Sturgeon, 2014). Moreover, LCRs can take the shape of either hard institutions – such as requirements for local content or local investments on a project, often the case in developing countries – or soft institutions – in which governments apply pressure on lead firms and developers to select local suppliers without imposing formal conditions, often the case for countries restricted by free trade agreements (Baker and Sovacool, 2017; Hestermeyer and Nielsen, 2014; Landini et al., 2020; Penman, 2021; Roberts and Valpy, 2015; Stephenson, 2016).

An extensive debate has formed around the effectiveness of local content regulations to successfully develop local industries, and particularly in the higher value-added segments often requiring a relational mode of governance (Kuntze and Moerenhout, 2013). In the context of offshore wind, increased transaction costs are extremely relevant (European Commission, 2016). Transaction costs borne by the developer will rise when faced with local content requirements because there is a cost associated with limiting the scope of potential suppliers (Ankeny, 2016). Developers tend to rely on global networks to maximize cost efficiencies and access capable suppliers. If local content requirements encourage or require a developer to select suppliers from a specific location, costs may be higher than if sourced freely from the global market (Ankeny, 2016; Kuntze and Moerenhout, 2013; Munson and Rosenblatt, 1997). As transaction costs are inherently higher in value

chain segments classified by a relational mode of governance, switching suppliers is more costly (Eriksson and Edlund, 2013; Gereffi et al., 2005). Therefore, it may be easier to incorporate local suppliers that require a market mode of coordination due to lower transaction costs. Unless local content requirements target certain supply chain segments, developers may opt for market coordinated segments to minimize costs. Consequently, they would be able to meet their local content obligations while retaining control over the higher cost supply chain segments.

However, when the windfarm developer is headquartered in the same country as the windfarm, it is expected that local content requirements provide an additional boost for local supplier selection regardless of the mode of governance due to the compound benefits of geographic, historical and political proximity with local content mandates. Therefore, when there is a local developer and local content is pushed for, it is expected that the effectiveness of increasing the share of local suppliers is high across the entire value chain, regardless of the mode of governance into which the supplier is categorized. This leads to the following proposition:

Proposition 4. *Local sourcing is more likely to occur under the presence of local content requirements, with the largest effect occurring in the market-coordinated mode of governance. When a project is developed by at least one local developer, the presence of local content requirements is likely to have a strong and positive effect across the value chain, regardless of the mode of governance.*

The flowchart below depicts our hypotheses depending on whether the project in question is developed by a local or foreign developer and whether there is the presence of local content regulations. A larger offshore wind market is considered to have a positive effect on local sourcing across all modes of governance and developer originFig. 1.

3. Methods

3.1. Data

This research investigates the statistical differences in supplier sourcing for different segments of the offshore wind value chain, tested using data primarily derived from the 4C Offshore Wind 2019 database (4C Offshore Ltd., 2019,), a dataset of all offshore windfarms across the globe, including all stakeholders, their respective value chain roles and country of origin.

Only commercial-scale (>30 MW) European windfarms in the 'fully commissioned', 'partial generation/under construction', 'pre-construction' and 'under construction' phases are included to ensure that the full supply chain for each project is represented, and demonstration farms are factored out; six countries – Belgium, Denmark, Germany, the Netherlands, Sweden and the United Kingdom – are included, resulting in an initial sample of 97 windfarms, 1,223 unique firms and 13,444 awarded contracts.

The database has pre-assigned stakeholder roles per contract, such as 'manufacturer-turbine (blades)'. Subsequently, we recategorize the original stakeholder types into more concise value chain segments based upon industry reports and literature (Accenture, 2013; Amico et al., 2017; BVG Associates, 2019; Lema et al., 2011; Poulsen and Lema, 2017; Weig, 2017). For example, the categories 'port' and 'port services' are combined into 'port services'. In total, the 238 unique stakeholder categories are recategorized into 38 consolidated categories. The developer role is assigned 'developer', using the company's headquarters for its location (Poulsen and Lema, 2017). These stakeholder roles are the value chain segments for offshore wind. Appendix B lists the full re-categorization that is applied.

To factor in the reality that different countries have different industrial capabilities, we verify whether each country has the industrial capability for each stakeholder category. This prevents creating biases in the results, particularly in measuring local sourcing if a developer does
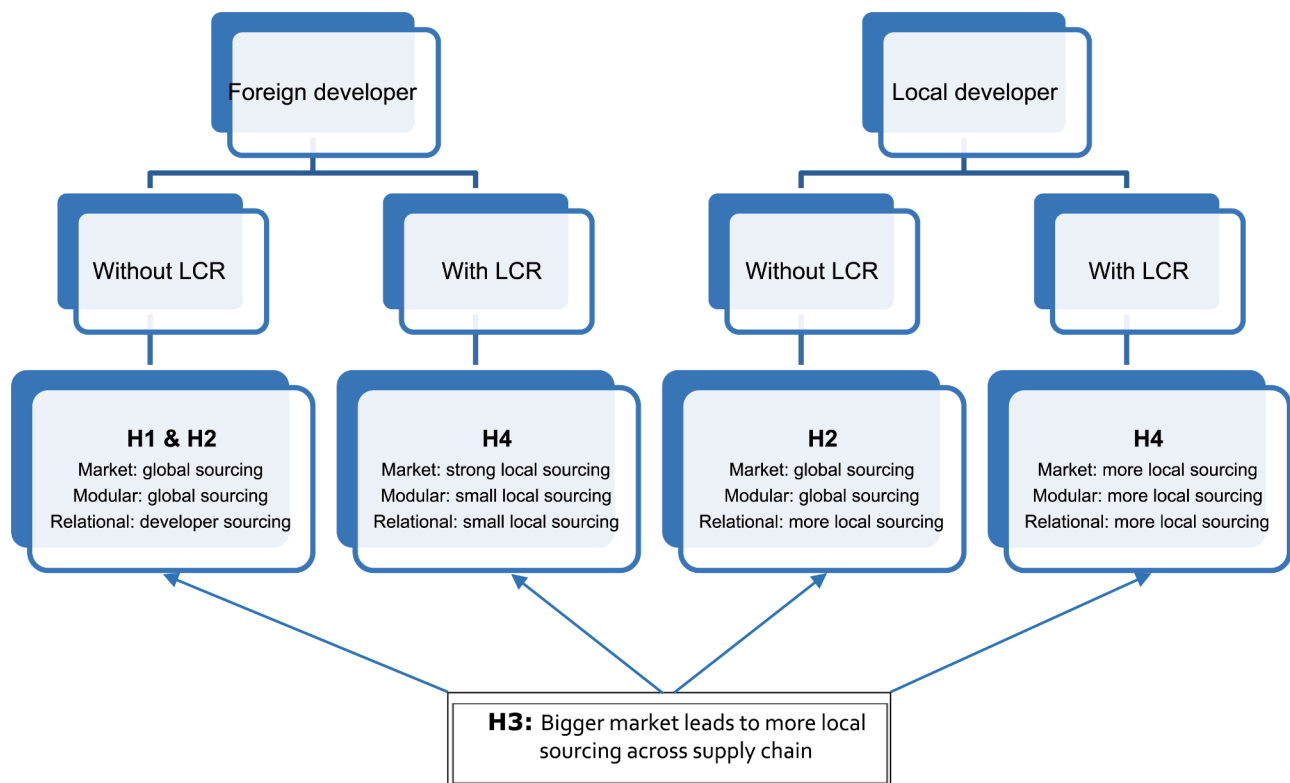
Fig. 1. A schematic depiction of the hypotheses.

not even have the option to select a local supplier. Specifically, we first verify whether any company from each of the six countries has ever been awarded a contract for each of the 38 stakeholder categories. If no company based in the country has ever been awarded a contract for that stakeholder role, it is assumed that the country does not have the appropriate industrial capabilities. We then filter out these stakeholder roles for the project country in question. For example, if no Dutch company has ever been awarded a contract for 'turbine supply' (in any of the six project countries), then this stakeholder category is removed from the analysis of the seven Dutch windfarms. In total, 1418 contracts are removed, resulting in a valid N of 12,026 awarded contracts by 968 unique firms across 93 windfarms in six countries.

3.2. Dependent variable

The dependent variable is the type (location) of sourcing. Four categories of sourcing are defined: (1) '*Local sourcing*' occurs if a developer selects a supplier in the market where it develops an offshore wind project. (2) '*Developer sourcing*' occurs when a developer hires a supplier from its own country. (3) '*Local-developer sourcing*' occurs when the developer is headquartered in the same country as the windfarm and selects a supplier from that country. (4) '*Global sourcing*' accounts for all other suppliers. In the case of joint-venture development teams, the countries of the headquarters of all firms in the development team were listed. If a supplier then originates from one of these countries, it is assigned 'developer sourcing' (or 'local-developer sourcing' if the windfarm country is the same as the headquarters of one of the developers and the supplier).

3.3. Independent variables

3.3.1. Mode of governance

The *mode of governance* is the core categorical independent variable – *market, modular* or *relational* – and is determined by two governance indicators: *complexity* and *codifiability*. This research only includes complexity and codifiability to determine the mode of governance because it is assumed that, if a supplier is selected, it has the capabilities to perform the task. We exclude the captive and hierarchical modes as they are integrated into – or directly controlled by – the developer, thereby requiring high switching costs, similar to the relational mode of governance. Further, it is not possible to distinguish suppliers governed by the captive or hierarchical modes in the database. We assign one of the three modes of governance to each of the 38 stakeholder categories by first determining their complexity and codifiability.

Both complexity and codifiability are assigned binary values. Complexity is measured using the number of individual contracts and the number of unique firms per stakeholder category. If more firms are contracted and have the competencies to perform a task, we assume that the activity relies on a more easily replicated skill set (MacKinnon et al., 2019). If the number of individual contracts or unique firms is smaller than the average number of individual contracts or unique firms for all stakeholder categories, the complexity is high. Therefore, if the number of individual contracts and unique firms for a specific stakeholder role are higher than the average number of individual contracts or unique firms for all stakeholder roles the complexity of that stakeholder role is low. We then verify the classification for each stakeholder category through industry reports and scientific literature (Barlow et al., 2015; BVG Associates, 2019, 2020; EWEA, 2009; Halvorsen-Weare et al., 2013; Hunstad and Risan, 2014; IRENA, 2018, 2019b; IWMA 2017; Offshore Wind Programme Board, 2015; Paterson et al., 2018; Scholz-Reiter et al., 2010; Sovacool and Enevoldsen, 2015; Steen, 2016; Triepels, 2017; WindEurope, 2017). Five of the 38 stakeholder roles require requalification following literature research. In these instances, we use the evidence provided in the literature.

Codifiability is also assigned a binary value through literature research, primarily based upon academic articles and industry reports.

For each stakeholder role, we evaluate the degree of product and process standards, the influence of specific conditions such as reputation and cultural institutions that can exist at the country level, project level or even inter-firm relationships – and modularity of product architectures. Stakeholder roles that are easily standardized, modularized and share a common knowledge base indicate a high degree of codification, whereas roles that have limited standardization and rely on bespoke or turn-key production systems have a low degree of codifiability (Gereffi et al., 2005; Pietrobelli and Rabellotti, 2011; Welie et al., 2019). Table 2 shows an example of the codification used to determine the mode of governance. Appendix C contains the full table.

3.3.2. Local content push

The second independent variable is the presence of *local content push*, measured as a dummy variable for each country, determined through industry journals, government reports and academic literature. All six countries in this study are signatories to the Trade-related investment measures (TRIMS) and General Agreement on Tariffs and Trade (GATT) – which restrict unfair and unequal protectionist trade measures – are members of the World Trade Organization and of the European Union free trade zone (as of 2019), none can therefore impose legally binding local content requirements (Fuenfschilling and Binz, 2018; Hestermeyer and Nielsen, 2014). However, The United Kingdom has demonstrated a strong desire to push local content sourcing and the development of a local offshore wind industry; it further imposes local content reporting requirements and other measures designed to steer sourcing towards local suppliers (Department for Business Energy and Industrial Strategy, 2021; Penman, 2021; Roberts and Valpy, 2015). While the other five countries reference the value of offshore wind to stimulate local industries, none of them exhibits such an explicit drive for local content selection. Therefore, the United Kingdom is the only country to receive a '1'for local content push.

3.3.3. Market size

The third independent variable is *market size*, which is measured by the total installed capacity in megawatts (MW) in each country from the first commercial offshore wind farm in 2002 until 2019, including those still under construction.

3.4. Control variables

Economic wealth (€GDP/capita) is added as a control variable and is gathered from the Eurostat (2019) database. Some research suggests that wealthier countries are more likely to develop a strong value chain because they can afford to invest in its development (Vachon and Mao, 2008). Table 3 provides a summary of all variables.

3.5. Data analysis

Three datasets are used to test our propositions. Proposition 1 is tested with the full dataset (N= 12,026). To test for Propositions 2–4, the full dataset is separated based on whether a windfarm is developed by a foreign developer (N= 5529) or whether a windfarm is developed by at least one local developer (N= 6497) because local sourcing cannot co-exist with local-developer sourcing.

Given the nominal (categorical) character of the dependent variable, logistic regressions are used to test the propositions and to determine how the three independent variables impact the type of sourcing. Multinomial logistic regressions are used to add nuance to the binomial logistic regressions by comparing all types of sourcing to global sourcing. Global sourcing is set as the reference category to assess the tendency developers might have to draw with them suppliers from their home country or the windfarm country. Microsoft Excel is used to clean the database and SPSS is used to run the statistical tests.

Table 2
Example of mode of governance classification.

Value chain part	Complexity (*number of firms*)	Complexity (*number of unique firms*)	Complexity (*literature*)	Codifiability (*literature*)	Mode of Governance
Meteorological station	1	1	1	1	Modular
Foundation	0	0	0	1	Market
Substation	1	1	1	0	Relational
Transition piece	1	1	1	1	Modular
Turbine	1	1	1	1	Modular
Cable	1	1	1	1	Modular
Consultancy	0	0	0	1	Market

Table 3
Summary of variables.

Variable name	Variable type	Level of measurement	Measurement
Type of sourcing	Dependent	Nominal	1 = Developer sourcing 2 = Local sourcing 3 = Global sourcing 4 = Local–developer sourcing
Mode of governance	Independent	Nominal	Market: low complexity (0), high codifiability (1) Modular: high complexity (1), high codifiability (1) Relational: high complexity (1), low codifiability (0)
Local content push	Independent	Nominal (dummy)	Presence of local content requirements (no = 0, yes = 1)
Market size	Independent	Ratio	Total installed capacity in 100 megawatts per country
Economic wealth	Control	Ratio	Economic wealth in €GDP/ capita

4. Results

4.1. Descriptive statistics

Table 4 provides descriptive statistics of the six countries. The United Kingdom has the largest market for offshore wind, followed by Germany, Denmark and the Netherlands. Most of the contracts are awarded in the market-coordinated parts of the value chain, followed by the modular and relational parts. The United Kingdom is the only country that imposes a local content push (Eriksson and Edlund, 2013; EWEA, 2015; Kern et al., 2014; Kuntze and Moerenhout, 2013; PWC, 2018).

Table 5 provides a breakdown of the mode of governance by windfarm country. More than half of all contracts are awarded globally. Suppliers are rarely drawn from the same country as the developer unless the developer develops a windfarm in its home country. Although the United Kingdom is the only country in the sample with local content requirements, the share of the sum of local contracts and local-developer contracts is only slightly higher than in Denmark. The other countries award fewer local and local-developer contracts as a percentage of the total number of contracts.

4.2. Logistic regression model building and assumption testing

Three datasets are used to test our propositions: the full dataset (N= 12,026), followed by a split dataset based on whether a windfarm is developed by a foreign developer (N= 5529) or by at least one local developer (N= 6497). The model building, explanatory power and model fit for each binomial model are given in Appendix D.

Each of the models has a Chi-square that is significantly larger than zero, indicating that each model explains significantly more than its baseline model. Importantly, the changes in the Chi-square from the fourth to the full model for *local sourcing* for both the binomial and the multinomial logistic regressions are not significant, suggesting that all variables except *economic wealth* significantly contribute to enhancing model fit. Appendix F provides an overview of the Hosmer–Lemeshow goodness-of-fit statistics for the binomial logistic and multinomial logistic regressions, which show that the goodness-of-fit statistics are highly insignificant, thereby approving that the fit of the binomial logistic models is sufficient.

4.3. Assumptions testing

Valid sample sizes of N= 12,026 for the full dataset, N= 5529 for foreign-developed windfarms and N= 6497 for windfarms developed by at least one local developer indicate a sufficient number of cases per independent variable (Schreiber-Gregory and Karlen, 2018).

Further, logistic regressions assume linearity of any continuous independent variables. In this case, *current installed capacity* and *economic wealth* are the only continuous independent variables. Appendix G, Tables G1, 2 display our log-linearity diagnostics.

Second, we test for multicollinearity of our independent variables. Appendix G, Tables G3–6 show the multicollinearity tests. The variance inflation factor of both *current installed capacity* and *economic wealth* are higher than 10 for foreign developed windfarms with a correlation of -0.972, indicating severe issues of multicollinearity. Therefore, *economic wealth* is excluded as a predictor from the analysis for foreign developed windfarms. All other variables do not show a risk of multicollinearity.

Finally, our assumption testing of Cooks distance and leverage values shows that there are no outliers or highly influential points.

Table 4
Country level variables.

		# of windfarms	Contracts by mode of governance			Current installed capacity (100MW)	Local content push	Economic wealth (€1000/ capita)
			Market	Modular	Relational			
Windfarm country	**Belgium**	11	444	173	163	8.71	No	35.60
	Denmark	8	381	203	190	13.82	No	48.26
	Germany	26	2053	903	567	61.77	No	35.86
	Netherlands	7	482	170	131	11.01	No	41.54
	Sweden	3	54	39	27	1.88	No	43.81
	United Kingdom	38	3732	1388	926	79.01	Yes	32.70
	Total	93	7146 (59%)	2876 (24%)	2004 (17%)	176.2		39.63 (avg.)

Table 5

Supplier sourcing type by windfarm country.

		Type of contract sourcing								Total	Total
		Developer		Global		Local		Local-developer			
		#	%	#	%	#	%	#	%	#	%
Windfarm Country	Belgium	65	8.3	500	64.1	0	0	215	27.6	**780**	**100%**
	Denmark	20	2.6	311	40.2	116	15.0	327	42.2	**774**	**100%**
	Germany	200	5.7	2409	68.4	136	3.9	778	22.1	**3523**	**100%**
	Netherlands	28	3.6	391	50.0	38	4.8	326	41.6	**783**	**100%**
	Sweden	0	0.0	73	60.9	13	10.8	34	28.3	**120**	**100%**
	United Kingdom	501	8.3	2046	33.8	2462	40.7	1037	17.2	**6046**	**100%**
Total		**814**	**4.75% (avg.)**	**5730**	**52.9% (avg.)**	**2765**	**12.53% (avg.)**	**2717**	**29.83% (avg.)**	**12026**	**100%**

4.4. Binomial and multinomial logistic regressions

The results of the binomial logistic regressions are given in Tables 6–9. The odds ratio – *Exp (B)* – represents the odds that the outcome occurs as a function of the predictor variable. A value greater than 1 indicates that, as the predictor increases, the odds of the outcome occurring increase. Conversely, a value less than 1 indicates that the odds of the outcome occurring decrease. Each table represents the odds of each of the dependent variables – *developer sourcing, global sourcing, local sourcing* or *local-developer sourcing* – occurring in relation to the independent variables and their interaction terms. The multinomial logistic regression results are displayed in Table 10. Multinomial logistic regressions break the outcome variable into a series of comparisons between two possible outcome categories and compare all types of outcome categories to a chosen reference category, thus adding more nuance to the binomial logistic regressions (Field, 2013).

5. Analysis

Proposition 1: *Global sourcing most likely occurs in the market-coordinated parts of the value chain, followed by the modular parts.* – *confirmed.*

The probability of global sourcing is the highest in the market coordinated parts of the supply chain, followed by the modularly coordinated parts. In the market coordinated parts of the value chain, transactions are primarily based on price, suggesting that spatial proximity does not play a role in supplier selection, leading to a higher probability of global sourcing. For example, a developer looking for a crew-transfer vessel will scour the global market for the most cost-efficient supplier. Importantly, this effect is superseded by the interaction with local content push (see Proposition 4).

Proposition 2: *Relationally coordinated suppliers are more likely to be selected by developers from the same country of origin, followed by the modular and market coordinated parts.* – partly confirmed.

Proposition 2 cannot be confirmed for foreign developers selecting suppliers from their own country at a statistically significant level except for a nearly significant effect ($p = 0.062$) for modular sourcing. For example, Danish developer Ørsted may tend to favor the modularly coordinated Danish MHI-Vestas wind turbines for its windfarms; however, this is only a tentative indication as the results are only significant at $p = 0.062$, suggesting the need for additional studies in the future when more windfarms in more countries and more wind turbine manufacturers are present. For example, whether American developers are more likely to select American wind turbine manufacturer General Electric may be particularly enlightening.

The probability of a local developer selecting local suppliers (*local-developer sourcing*) is the highest in the relational modes of governance. While relational suppliers are still more likely to originate from the global market, they have the highest chance of being represented at the local level when a local developer is present. This may suggest that developers and suppliers from the same country are more likely to work together within, rather than outside, their geographic origin due to additional interaction effects, such as a common knowledge of local institutions.

However, interactions between developers and suppliers are not always nested in the same geographic context that governs complex and

Table 6

Binomial logistic regression results for developer sourcing.

	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Market (reference)			3,997	2	,136			
Modular	,254	,136	3,484	1	,062	**1,289**	,987	1,682
Relational	,195	,156	1,560	1	,212	1,215	,895	1,649
Local content push (1)	,135	,138	,957	1	,328	1,145	,873	1,500
Local content push (0) × market (reference)			6,362	2	,042			
Local content push (1) × modular	-,197	,180	1,195	1	,274	,822	,578	1,169
Local content push (1) × relational	,362	,195	3,429	1	,064	1,436	,979	2,106
Current installed capacity (100MW)	-,006	,003	4,486	1	,034	**,995**	,989	1,000
Economic wealth (1000€GDP/capita)	-,111	,021	28,683	1	,000	,894	,859	,932
Constant	1,443	,840	2,951	1	,086	4,235		

Table 7
Binomial logistic regression results for global sourcing.

	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Market (reference)			31,790	2	,000			
Modular	-,220	,047	11,340	1	,001	**,803**	,707	,912
Relational	-,384	,053	27,968	1	,000	**,681**	,591	,785
Local content push(1)	-2,340	,059	1167,647	1	,000	,096	,084	,110
Local content push			313,190	2	,000			

Table 8
Binomial logistic regression results for local sourcing.

	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Market (reference)			1,629	2	,443			
Modular	,003	,166	,000	1	,985	1,003	,724	1,389
Relational	,233	,189	1,515	1	,218	1,262	,871	1,828
Local content push (1)	2,961	,147	406,122	1	,000	**19,309**	14,478	25,752
Local content push (0) × market (reference)			72,956	2	,000			
Local content push (1) × modular	-1,217	,183	44,286	1	,000	,296	,207	,424
Local content push (1) × relational	-1,461	,209	48,754	1	,000	**,232**	,154	,350
Current installed capacity (100MW)	-,029	,003	101,858	1	,000	**,972**	,966	,977
Constant	,082	,150	,299	1	,585	1,086		

Note: Variable(s) entered on step 1: Mode of governance, Local content push, Mode of governance * Local content push, Current installed capacity (100MW), n = 5529.

hard to codify relational interactions, as expected for effective cooperation (Boschma, 2005; Pietrobelli and Rabellotti, 2011). Despite evidence that some offshore wind developers disproportionately source suppliers from their own country – such as the Norwegian developer Equinor – this is not a statistical generalization that we can draw (Hanson et al., 2019). Potentially, relational suppliers are chosen by a developer because they have previously worked together, which is sometimes, but not always, embedded in a specific geographic context (Pietrobelli and Rabellotti, 2011). Many actors have not only previously collaborated on offshore wind, but also in oil and gas or other related global industries (Hansen and Steen, 2015; Mäkitie et al., 2018). Indeed, transactions that involve high levels of asset specificity are often managed through repeated transactions, reputation and social norms (Gereffi et al., 2005). This means that organizational proximity can be, but is not automatically, facilitated by shared national roots.

Proposition 3: (*A) Sourcing suppliers from the country where the market is (local sourcing) becomes more likely at a higher installed capacity for all modes of governance. (B) This trend is exacerbated when the project is developed by a local developer.* – (A) rejected; (B) not confirmed.

The probability of local sourcing turns out to be lower for a larger market at a small, but statistically significant, level. Thus, the first part of proposition three is rejected. The results are not statistically significant to be able to assess the effect of current installed capacity on local-developer sourcing.

The effect of *current installed capacity* on local sourcing gives unexpected results. The probability of local sourcing is lower with higher values of installed capacity, while global sourcing is higher. The United Kingdom and Germany have the largest markets, but they are proportionally more likely to source suppliers globally compared to other countries. It therefore does not suffice to only invest in a large market and expect an automatic increase in local content. Since offshore wind has now exited the emergence phase of development and entered the acceleration phase, it is possible that local industries can no longer rely on a protected niche-space.

Proposition 4: *Local sourcing is more likely to occur under the presence of local content requirements, with the largest effect occurring in the market-coordinated mode of governance. When a project is developed by at least one local developer, the presence of local content requirements is likely to have a strong and positive effect across the value chain, regardless of the mode of governance.* - partly confirmed.

We find that the probability of local sourcing (by a foreign developer) is 19 times higher when there is a push for local content across the supply chain and 8 times higher for a local developer, demonstrating the tremendous impact of local content regulations.

Therefore, the effects found for proposition one are superseded by the interaction with local content push because local content requirements are more effective in stimulating local sourcing in the market-coordinated parts than the relational or modular parts. The results are not statistically significant to assess if the probability of local sourcing is higher in the modular parts of the value chain. Local content regulations may be more effective in the market-coordinated parts of the value chain because it is easier to find local substitutes.

Table 9

Binomial logistic regression results for local-developer sourcing.

	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Market (reference)			22,932	2	,000			
Modular	,214	,075	8,095	1	,004	1,239	1,069	1,436
Relational	,371	,082	20,330	1	,000	1,449	1,233	1,703
Local content push (1)	2,100	,093	515,000	1	,000	8,167	6,813	9,792
Local content push (0) × market (reference)			94,165	2	,000			
Local content push (1) × modular	- 1,280	,145	77,653	1	,000	**,278**	,209	,370
Local content push (1) × relational	-,997	,163	37,327	1	,000	**,369**	,268	,508
Current installed capacity (100MW)	,001	,002	,253	1	,615	1,001	,998	1,004
Economic wealth (1000€GDP/capita)	,121	,009	170,471	1	,000	1,129	1,109	1,150
Constant	- 5,405	,396	185,929	1	,000	,004		

Note: Variable(s) entered on step 1: Mode of governance, Local content push, Mode of governance * Local content push, Current installed capacity (100MW), Economic wealth (1000€GDP/capita), n = 6497.

Critically, it appears that local developers are less likely to select local relational suppliers when local content is pushed for, whereas they have a greater tendency to do so in the absence of local content regulations; this hints at a tricky interplay of adhering to policy requirements whilst minimizing transaction costs.

The flowchart below schematically summarizes our results and color codes the hypotheses according to whether they are confirmed, partially confirmed, rejected or unable to be confirmedFig. 2.

6. Discussion

This research has unpacked the specific properties of firm linkages that influence local industry growth when supply chain selection is in the hands of developers. We argue that different modes of industrial governance influence the geographic properties of supply chain selection. This research makes a first attempt at breaking down the offshore wind global value chain – as distinct from its onshore wind counterpart – across the modes of governance that characterize it (Bair and Sturgeon, 2008; Gereffi et al., 2005).

In addition, local sourcing is often pitted against global sourcing (Amico et al., 2017; Nassimbeni, 2006; Sengers and Raven, 2015; Steinle and Schiele, 2008); we further nuance this dichotomy, both for offshore wind and for global industries in general, by introducing the notion of *developer sourcing*, wherein the lead firm selects suppliers from its own country (Hanson et al., 2019; Van der Loos et al., 2021). While our results do not find statistical evidence that developers engage in favoritism, local industry growth is more likely to succeed when developers and suppliers originate from the same country as the windfarm project for both the market and relationally coordinated segments of the value chain. While the relational parts are still more likely to be sourced globally, their best shot at being selected locally is if the developer is also local. Policy makers may therefore be inclined to grant the developer contract to a local developer, standing in contrast to the core notions of free market economics and open competition.

Second, the effectiveness of local content regulations differs depending on the mode of governance, shedding new light about its utility. On the one hand, increasing demand for renewable energy requires generation costs to be kept as low as possible. On the other hand, governments often have an interest in stimulating local industries (Kuntze and Moerenhout, 2013; Van der Loos et al., 2020a). The latter can increase transaction costs borne by the developer, leading to higher generation costs (Kuntze and Moerenhout, 2013). The results indicate that developers may try to avoid increases in transactions costs as much as possible by selecting more local suppliers for the market-coordinated parts of the chain, such as crew transfer vessels. Since transactions costs are inherently higher in the relational value chain segments and there are typically fewer suppliers with the required competencies, states tend to have less leverage to demand local content.

Therefore, governments seeking to bolster emerging industries need to find a delicate balance between development costs and local content requirements (Kuntze and Moerenhout, 2013). To compensate, government subsidies and financial support are sometimes used to attract foreign developers to the local market (Kochegura, 2017). Alternatively, a technology-push strategy, including investing in knowledge production and diffusion, could improve the competitiveness of the local industrial base in both the lower and higher value added segments (Van der Loos et al., 2020a; Pietrobelli and Rabellotti, 2011). This stresses the importance of the wider policy context to increase local industrial participation in the global value chain.

A particularly interesting finding is that the inclusion of local content push appears to reduce local relational supply chain selection by local developers than when they are allowed to operate independently from such policies. Within our dataset, this means that a British developer building a British offshore windfarm is less likely to select a British relationally coordinated supplier than a German developer on a German windfarm, where no local content push is present. Potentially, while

Table 10

Multinomial logistic regression results (reference category: global sourcing).

		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Developer Sourcing[a c]	**Relational (reference)**	0[b]			0				
	Modular	-,599	,318	3,537	1	,060	,549	,294	1,026
	Market	,113	,272	,173	1	,678	1,120	,657	1,909
	Local content push (1) (reference)	0[b]			0				
	Local content push (0)	-,890	,431	4,264	1	,039	,411	,176	,956
	Local content push (0) × market	-,443	,437	1,027	1	,311	,642	,273	1,512
	Local content push (0) × modular	,587	,496	1,404	1	,236	1,799	,681	4,752
	Current installed capacity (100MW)	-,007	,006	1,337	1	,248	,993	,982	1,005
	Economic wealth (1000€GDP/capita)	-,072	,046	2,431	1	,119	,930	,850	1,019
	Intercept	1,606	1,81 1	,787	1	,375			
Local Sourcing[a d]	**Relational (reference)**	0[b]			0				
	Modular	-,093	,148	,400	1	,527	,911	,682	1,217
	Market	1,213	,132	84,037	1	,000	3,363	2,59 5	4,359
	Local content push (1) (reference)	0[b]			0				
	Local content push (0)	-1,342	,319	17,669	1	,000	,261	,140	,489
	Local content push (0) × market	-1,530	,303	25,472	1	,000	,217	,120	,392
	Local content push (0) × modular	-,209	,341	,374	1	,541	,812	,416	1,584
	Current installed capacity (100MW)	-,025	,004	38,829	1	,000	,975	,967	,983
	Intercept	1,796	,340	27,892	1	,000			
Local / developer Sourcing[a e]	**Relational (reference)**	0[b]			0				
	Modular	-,525	,355	2,186	1	,139	,592	,295	1,186
	Market	,750	,312	5,801	1	,016	2,118	1,15 0	3,900
	Local content push (1) (reference)	0[b]			0				
	Local content push (0)	-1,314	,330	15,914	1	,000	,269	,141	,512
	Local content push (0) × market	-1,142	,355	10,355	1	,000	,319	,159	,640
	Local content push (0) × modular	,376	,403	,863	1	,353	1,457	,659	3,221
	Current installed capacity (100MW)	-,001	,003	,129	1	,719	,999	,993	1,005
	Economic wealth (1000€GDP/capita)	,112	,019	34,193	1	,000	1,119	1,07 8	1,162
	Intercept	-3,257	,853	14,580	1	,000			

Note: a. The reference category is: Global. b. This parameter is set to zero because it is redundant, c. N = 12026, d. N = 5529, e. N = 6497

local developers may normally be willing to pay a premium for local, high value relational suppliers, the imposition of local content requirements stimulates them to select more market-coordinated local suppliers; these additional costs may need to be offset by replacing local relational suppliers with more cost efficient global relational suppliers.

The policy implications suggest that a country seeking to stimulate market coordinated value chain segments – which can have positive effects on local employment and regional economic benefits – could benefit from imposing local content policies. However, a country seeking to develop higher value, complex relational supply-chain
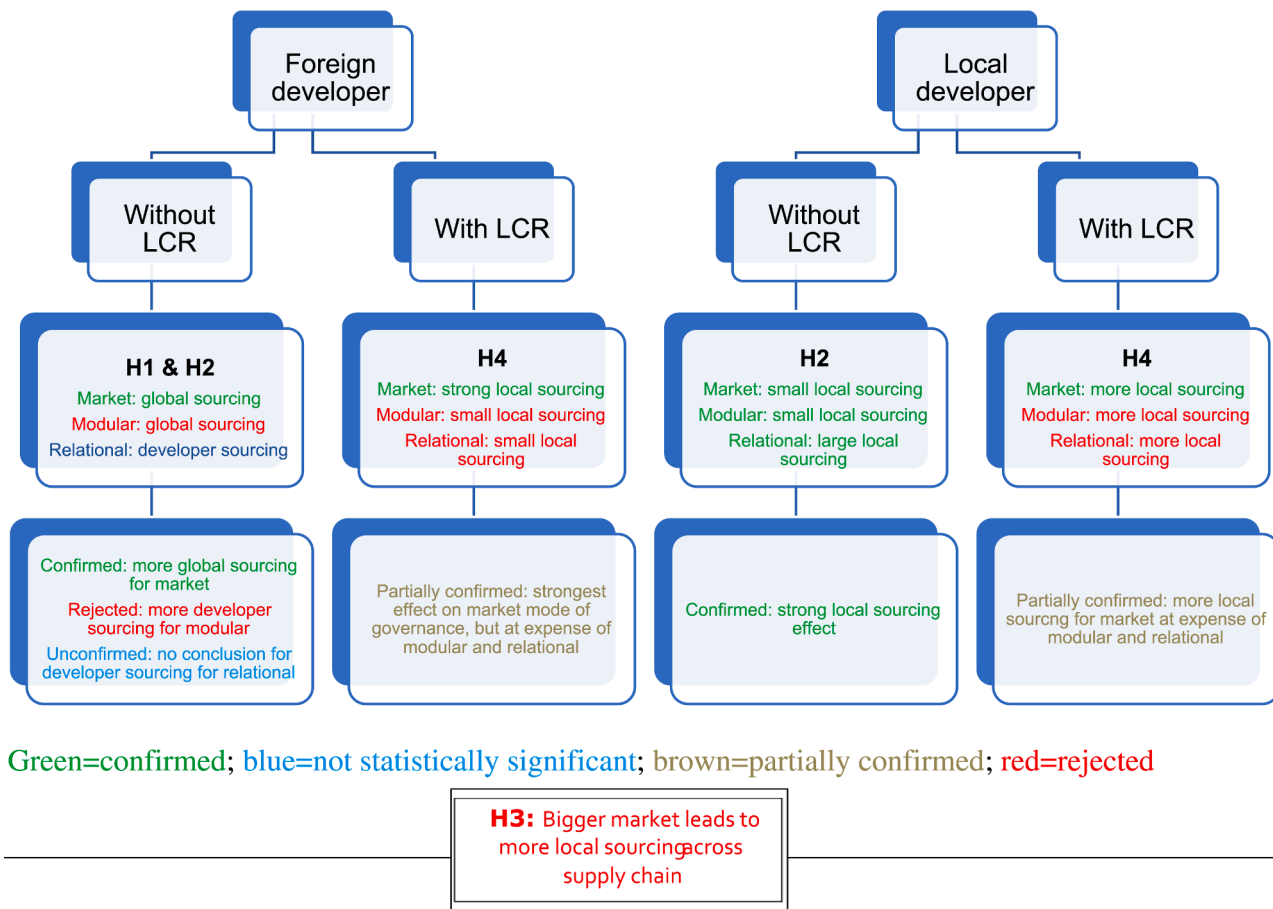
Fig. 2. A schematic depiction of the results according to the hypotheses.

segments may benefit more by selecting local developers without imposing local content regulations. Needless to say, a country needs to have the respective competencies, meaning that a robust and holistic industry building program is essential.

In addition, the results also show that a larger market does not automatically lead to an increase in local content, suggesting that it does not suffice to simply create a market and expect the industry to follow. A lead-market approach can therefore not be disentangled from a technology-push approach.

This research is based on the 2019 4C Global Offshore Wind Farms Database, leading to certain limitations. First, the United Kingdom is the only country in the sample with a local content push and commercial-scale windfarms. As more countries outside of Europe begin to enter the offshore wind market, new insights may be gained. However, within Europe, we do not expect the results to change because British windfarms have been built by both foreign and local developers. We expect this phenomenon to hold true for other countries with local content efforts as long as countries operate within a liberal-market economy, and particularly one defined by free trade. For example, France has also expressed a strong local content push for offshore wind and future studies would help shed light on the success of these initiatives for its first commercial-scale offshore windfarms (Parnell, 2019). However, strong and specific local content policies that are exempt from international trade regulations, such as the case of China, may succeed in bringing in a greater share of high-value local suppliers. In another example, the Jones' Act (Merchant Marine Act of 1920) in the United States prohibits non-American manufactured, owned and operated vessels from shipping between American ports, which currently affects offshore windfarms (Jones, 1921). Given that vessels play a large role in offshore wind construction, developing American offshore windfarms

will require a different logic for certain segments of the offshore wind value chain. Therefore, our results are specific to the European context and different insights may be derived as trade or policy measures could restrict or stimulate a firm's access to global markets (Offshore WIND, 2019).

An additional limitation is that certain companies within value chain segments may be coordinated in different ways, leading to different modes of governance. For example, some firms within 'consultancy' may governed relationally due to their highly specialized nature, while others may be more standardized, thereby leading to a market mode (Haakonsson et al., 2020; Pavitt, 1984). A qualitative study into the specifics of different firms within a certain stakeholder category could help flesh out some of these nuances. Subsequently, these roles may also change over time, with suppliers increasing their competencies and thereby altering their relationship with a lead firm (Gallagher, 2006). Due to the limitations of the model, it is not possible to build in changes to the mode of governance over time. Nonetheless, we consider our results to be robust, particularly within the context of European offshore windfarms.

Finally, repeated relationships are likely to be an influential factor in supplier sourcing. It is common to initiate relationships with existing partners, but less is known about a developer's dependence on repeated transactions – within or outside of offshore wind – for suppliers across the different modes of governance. Further research could investigate the expectation that relational value chain parts rely more heavily on repeated transactions than modular or market-coordinated transactions. As many of these firms are diversifiers from other global industries, such as oil and gas or onshore wind, we expect there to be a positive link between developers and relationally coordinated suppliers who have previously worked together, regardless of their geographic origin.

7. Conclusion

Developing national industries in light of global value chains and global markets can be a difficult task. This task is particularly challenging when the control of projects – and hence, supplier selection – rests largely in the hands of lead firms. This leaves countries with limited tools to encourage these developers to select local suppliers when a project is realized in their country. This research utilized the concept of global value chain governance to assess the geography of value creation and local industry building. More specifically, supplier selection was investigated based upon the origin of the developer, the location of suppliers, local content requirements and the size of a country's market, while considering that supplier selection in different parts of the value chain are characterized by three different modes of governance: market, modular or relational (with captive and hierarchical excluded). We use the offshore wind market in Europe as our case study, as it is an exemplary case of a fragmented global industry led by lead firms. This model is a first attempt to quantitatively assess local industry development by breaking a global value chain into its respective modes of governance. The results indicate that developers draw from the global market mostly for the market-coordinated parts of the value chain. Local supplier selection is more likely if the developer is also local. Further, both local and foreign developers are more likely to draw suppliers from the project country when there is a push for local content, indicating that appropriate policies can have a positive impact on industrial development; however, these local content requirements mostly apply to the market-coordinated parts of the value chain. Critically, while local content policies have a positive effect on local supplier selection in market coordinated segments, they have a negative effect on local supplier selection in the relationally coordinated segments. This suggests that developing local industries – and particularly within the more complex, relationally coordinated segments of the value chain – requires more than simply enacting local content policies, but also concerted system building strategies, such as investments in knowledge production, activating networking opportunities and facilitating entrepreneurial activity.

Declaration of Competing Interest

Acknowledgments

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