Supply chain, sustainability, and industrial policy - the case of the UK offshore wind energy supply chain

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Abstract
UK policy makers and local authorities increasingly make a recourse to supply chain terminology when promoting sustainable development. Through a case study of the offshore wind industry in the UK, this paper shows that this recourse is based on artificial definitions that muddle the local-global dynamics of clusters with the economies of scale of global supply chains: these are two related but distinct concepts. We propose a different, meta-organisational, supply chain level of analysis which is more relevant and informative when considering and supporting investment in sustainable technologies.

Keywords: Clusters, Supply Chain, Wind Energy, Policy

Introduction

The United Kingdom is currently going through a phase of intensive investment in the offshore wind energy sector. This investment programme is motivated by the integration of the sustainability/low carbon agenda and energy security in all aspects of UK and EU economic planning.

In a study of the development of new renewable energy technologies performed for the UK Department of Trade and Industry, Foxon *et al*. (2005) use the national innovation systems literature to develop a framework used to identify key issues faced by the UK renewable energy sector. Their conclusion is that the UK is experiencing the following system failures: (1) failure to move technology along maturity levels of the innovation chain (e.g. from pre-commercial to supported commercialisation) and (2) lack of skills in terms of R&D and applied engineering professionals. The growth of the

German, Dutch, and Swedish wind turbine industry is cited as a 'best practice' benchmark and Bergek and Jacobson's (2003) research about the German wind industry is used to highlight conditions for success: (1) creation of variety in an early phase, (2) establishment of the social legitimacy of wind energy, (3) the use of advanced market creation policies, and (4) the use of industrial policy to favour the domestic industry. The purpose of this paper is to investigate the legitimacy and effectiveness of the last recommendation, the use of industrial policy to favour the domestic industry, in the case of the UK offshore wind industry. The purpose is not to challenge the description of the growth of the German wind energy industry as a success, but to question if the success criteria defined above are universal or contextual. In other words, is the German case study the only possible approach to develop a commercially successful wind energy sector?

This question is topical as there has been in recent years a significant policy push towards the creation of a UK offshore wind energy supply chain. This is captured in the following statement from the 2013 *Offshore Wind Industrial Strategy: Business and Government Action* report: '*As part of our new industrial policy, we want to see UK-based businesses grow to create a centre of engineering excellence that delivers cost reduction for UK projects and exports to overseas market. To achieve the vision set out in this strategy, we need to grow our manufacturing base to be world-leading in more areas of offshore wind supply and to achieve levels of UK content in our offshore wind farms which are similar to those achieved by our North Sea oil and gas industry where more than 70% of capital expenditures is through UK-based suppliers*' (HM Government, 2013, p. 2).

The same report estimates that only 30% of offshore wind spending is sourced from UK suppliers (p. 71). A number of reasons could be used to explain this low figure:

- The turbine represents a major part of the capital expenditure budget. A typical benchmark for an offshore wind project is 50% (Hodkinson, 2001). Estimates amongst authors vary (e.g. Blanco, 2009) due to what components can be included in a 'turbine' purchasing category. Although UK manufacturers of turbine existed in the 1990s, they have either ceased trading or been acquired by larger Scandinavian wind turbine manufacturers and no manufacturing firms in the UK are currently able to participate in what is the most substantial capital expenditure component.
- Foxon *et al*. (2005) comment's about lack of skills means that it is unlikely that a UK firm could challenge the first mover advantages of German and Scandinavian wind turbines manufacturers. The innovation base appears meagre although the government is attempting to address this issue through a variety of innovation support measures such as the *Offshore: GROW initiative* and the *Offshore Renewable Energy Catapult*.

This paper presents the findings from a research project investigating the potential supply chain capability of one of the UK Centres for Offshore Renewable Energy (CORE)(Robins *et al*., 2012) and of an ongoing INTERREG project, Channel-MOR. Channel-MOR aims to advise policy makers and SMEs of the Arc Manche region regarding the strategic opportunities offered by marine offshore renewable energies. In this paper, the scope of discussion is limited to offshore wind energy though.

This paper is organised as follows: in the second section, findings from a supply chain capability case study conducted at a regional level are presented. These findings are critically evaluated in the third section through an examination in the light of supply chain theory, sustainability theory, and the national innovation systems literature. This critical evaluation led us to formulate the recommendation that if supply chains are going to be used in the context of developing sustainable commercial sources of energy, the very definition of supply chain and of the level of analysis of industrial policy should be revised. The implications that this industry case study has for the development of a theory of sustainable supply chains are discussed in the conclusion.

Case Study

Context and Methodology

The UK has identified key regions that offer a significant potential for renewable energy, the Centres for Offshore Renewable Energy (CORE). COREs are defined as *'partnerships between Central and Local Government and Local Economic Partnerships (LEPs) that ensure businesses looking to invest in manufacturing for the offshore renewables industry receive the most comprehensive support possible*' and are characterised by *'the right infrastructure for offshore wind manufacturing, access to a skilled workforce, an experienced local supply chain and committed local leadership. They also offer access to excellent R&D facilities and collaborative opportunities across the UK*' (HM Government, 2011).

In this section, the findings of a supply chain capability analysis for the Kent and Medway CORE are presented. Kent is a pioneering region in terms of wind farm installation in the UK, with an overall park of 558 turbines based on 5 different farms (Kentish Flats, Thanet Offshore, London Array, Gunfleet Sands and Greater Gabbard). The first wind farm (Kentish Flats) was completed in 2005 and Kent offers a variety of projects at different stages of a wind farm's lifecycle. It therefore constitutes an excellent study ground to investigate regional supply chain capability and the potential impact of wind energy on the local economy. This project, initiated by Kent County Council, is one of many examples of CORE regions asking themselves how to stimulate industrial activity around wind farms.

Data collection included a variety of sources, including desk research, interviews with key stakeholders (local government, wind farm operators, suppliers), a mapping of the supply chain structure across the lifecycle, and observations made during two workshops promoting opportunities to work with local wind farms. The two key findings are: (1) the setting of unrealistic expectations regarding regional supply chain economic impact and (2) the negative impact of very high transaction costs.

Finding: Expectations and Perceptions

Some respondents considered that Kent and Medway-based wind farms have had an important and widespread impact on the local economy, especially around the port and city of Ramsgate. Other interviewees believed that this impact was in fact limited, and this for a variety of reasons: some felt that the impact was limited for the time being and that more opportunities would arise in the near future, whilst others expressed concerns over the fact that opportunities are 'well-guarded' and benefit large scale experienced first tier contractors only. When interviewing wind farms operators, they mentioned that they are under permanent pressure to demonstrate their good will and ability to contract with local firms. Overall, the diversity of answers and perspectives that we have collected point to a gap between expectations and perceptions of impact. What most parties need are clear, realistic, and finite benchmarks about the local spending and jobs that one should expect a competitive wind farm to bring to a local economy. Instead, the policy literature on wind farms supply chain made such an impression on readers that expectations tend to be unrealistic. In the words of one of our interviewees, '*a wind farm is perceived as a goose laying golden eggs. A goose came, laid eggs, but they were not made of gold*'. Table 1 illustrates this issue by comparing two capital expenditures projects and their impact in the offshore wind and automotive sector.

Table 1 – Industry Comparison Based on Estimated Figures

	Investment (£b) Capital Expenditure	Employees	Purchasing, Operations, and Maintenance budget p.a. (£m)
London Array	1.91	90	76.40
Toyota Manufacturing UK (Wales and Derbyshire)	2.1	3800	1047.2

Table 1 shows how drastically different these two industries are, both in terms of local jobs generated but also in terms of the total volume of purchases of parts and services required. For an equal spent on capital expenditures (a 'one off' opportunity) local supply chain opportunities remain modest in the offshore wind sector when compared to more traditional industries.

Finding: Transaction Costs

Interviews confirmed that there are some opportunities during the construction phase of a wind farm, many of which have already been or are being exploited: specialist fleet, labour, associated port services. Some further opportunities could be exploited, as for example involving local ports during the wind farm construction. A Kent-based company interested in being more involved in the construction phase of a wind farm would however have to tender directly to a non UK-based first-tier supplier. This first-tier supplier is however likely to have entered informal discussions with some of its legacy suppliers prior to the inception of the project and in any case prior to the financial investment decision (FID) point.

Once the construction phase is finished and the wind farm enters the so-called phase 2 (operations and maintenance under a Design, Build, Operate contract), further opportunities arise. Opportunities are mostly in the domain of office supplies and administrative services (legal, secretarial, accounting) at the handover stage between phase 1 (Construction) and phase 2. Opportunities in the technical domain are very limited due to contractual ties with the first-tier supplier, with one of the wind farm estimating that in the technical domain only 5% of the total purchases can be contracted out to UK-based suppliers.

It is only after the end of phase 2 that a significant increase in opportunities related to operations and maintenance takes place. Typically, after the first five years of operations, the responsibility for the operations of the turbine is passed on from the builder to the operator. Turbine manufacturers have a relationship and legacy advantage but their parts and services typically come at a cost. According to one of the interviewee, up to 80% of parts needed at this stage are not specific to the wind energy industry and could be purchased from non-turbine suppliers. However, due to the high reliability and efficiency requirements, wind farm operators will only replace components previously acquired from legacy suppliers with new, lower-priced suppliers very carefully. These new supply contracts are initially conducted and on a very small scale in order to give the operator the chance to test the reliability of the new suppliers' products.

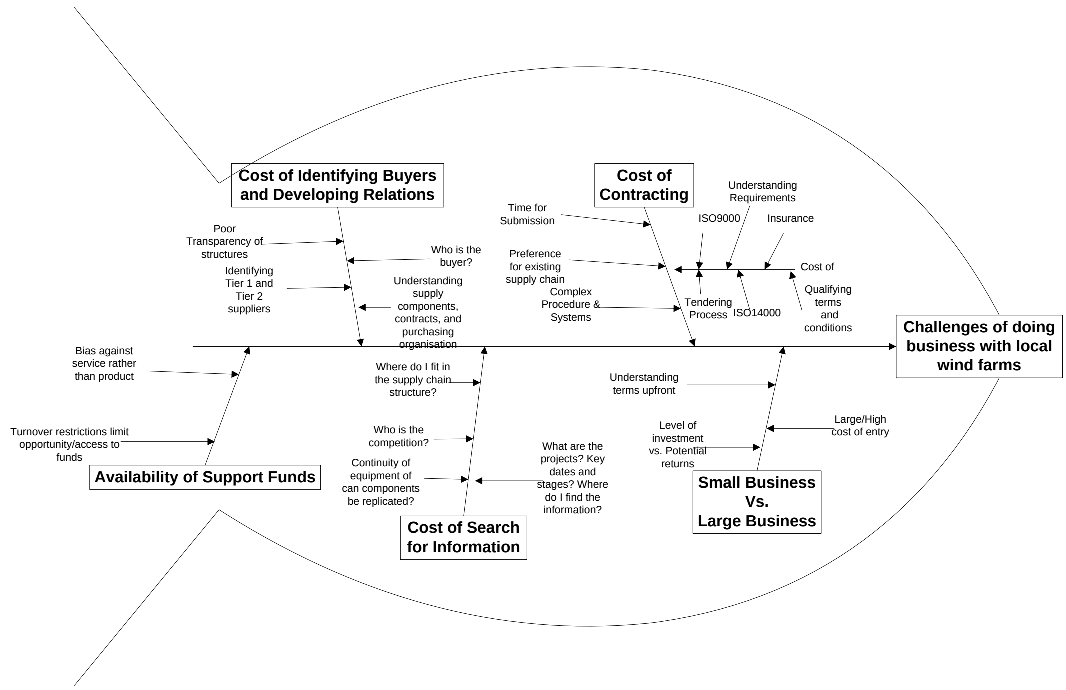

Figure 1 – Cause and Effect Diagram Summarising Workshop Findings (Ramsgate, June 6th 2013)

These findings were confirmed through one of the workshops where participants were asked to complete cause an effect diagrams analysing the challenges of doing business with local wind farms. Figure 1 summarises the key findings from 5 cause and effects diagrams prepared by a total number of 31 participants. Figure 1 reveals that the challenges for doing business with local wind farms are best described by transaction cost theory. These transaction costs include:

- the cost of searching for information and requirements,
- the cost of acquiring knowledge about the industry,
- the cost of identifying buyers and developing a business relationship with them,
- the cost of contracting and making sure that a bid complies with all the different requirements used in the wind energy sector, and
- the cost of putting systems in place in order to be able to transact and communicate with wind farms (e.g. insurance).

The fact that transaction costs in the wind energy sector are very high is accepted by wind farm operators. During the interviews many of operators actually appeared genuinely surprised that not more local firms can work with them although all readily agree that working with them can be quite cumbersome from an administrative perspective.

The second workshop attempted a roadmapping exercise where participants were asked to identify links and define priorities for support mechanisms from a pre-completed template. Responses to this workshop tend to solely and systematically make a reference to being introduced to the right contact and being invited to bid. This is consistent with what was discovered during the interviews and with what was documented during the cause and effect diagram workshop. The second workshop also revealed a low awareness of commercial opportunities and of the industry in general.

Critical Evaluation of Findings

The development of a UK offshore wind industry originates in the desire to reduce carbon emissions, and as such, policy decisions inscribe themselves within sustainability theory. The introduction has shown that to stimulate the growth of this sector a traditional industrial policy approach has been used and is based on Porters's Diamond (Porter, 1998). Most of the UK policy effort has however focused on only 2 of the 4 dimensions of Porters' diamond: market regulations (through the renewable obligations) and the supply chain. UK supply chain policy encourages local content and innovation. Unlike France which has opted for setting local content requirements for its planned wind farms, the UK has followed its free trade tradition by deciding not to allow such requirements to be set (although the UK Department of Energy and Climate Change launched in November 2013 a one month consultation regarding the elaboration of a 'supply chain plan' setting such local content requirements for future projects; DECC, 2013).

Thus, although borne out sustainability concerns, the UK wind energy policy inherits objectives which are typically associated with national innovation systems: contribution to economic growth and number of jobs created by new technologies. The inclusion of job creation as an explicit objective is used by policy makers to offset the lack of competitiveness of the sector, and more generally, a limited social acceptance of the technology. In short, the argument is: although offshore wind electricity is expensive today, it reduces carbon emissions and generate local jobs. In the future, the cost of electricity from wind farms will reduce and the number of jobs will increase, providing further benefits to the UK economy.

This argument can be criticised from a sustainability theory perspective through what Ihlen's (2009) calls the rhetorics of sustainability and more especially the recourse to a process of definition. By suggesting that poor economic performance is offset by carbon reduction and job creation, UK policy markers make up their own definition of sustainability, one which is perceived to be likely to be accepted as meaningful by the public.

How credible is this definition? For example, let us assume that by 2020 the UK has reached its carbon emissions targets and that due to learning curves and technology improvements the offshore wind energy sector is market-competitive. Would this industry be labelled as unsustainable if all wind turbines were imported rather than made in the UK?

The answer to this question lies in the implicit definitions and trade-offs made between the three dimensions of sustainability (economic, social, environmental). The resulting ambiguity when it comes to defining sustainability matches a well known issue in the national innovation systems literature: the challenge is to identify what the appropriate level of analysis is. Carlsson *et al.* (2002) explain that when considering the potential performance of new technologies, the definition of systems scope, actors, and performance targets are often arbitrary.

It is therefore legitimate to ask to what extent the inclusion of local content requirements in UK wind farms is an artificial rather than a genuine variable rooted in sustainability concerns? Currently, the recommendation is that industrial policy should be used to create a 'local supply chain', a notion not typically associated with the supply chain literature, where '*the old norms of local for local manufacturing and sourcing have been swept away*' (Christopher *et al*., 2006). This is not to say that clusters and global supply chains are conflicting notions. There are in fact related concepts as the emergence of a cluster will typically create a rich collaborative supply chain which is very likely to become a global supply chain. To better understand the relation between supply chains and clusters, one should examine the conditions under which clusters emerge.

Steinle and Schiele (2002) propose a theoretical framework describing these conditions. Typically, clusters emerge around production rather than consumption sites. These production sites, currently centred around turbine and their integration in a windfarm and their connection to the grid did not, and still do not exist in the UK. Steinle and Schiele (2002) show that other conditions are (1) the divisibility of the process, (2) transportability of the product, (3) the reliance on long value chains, (4) the need to use multiple competencies, (5) network-level innovations, and (6) volatile markets that constrain actors to collaborate in terms of identifying innovative solutions to the problems faced by the industry.

When reviewing the literature about successful wind energy industries (e.g. Bergek and Jacobson, 2003) it is clear that these conditions have already been met by other regions (Germany and Scandinavia). These clusters benefit from first-mover advantage and it is known that firms operating away from clusters will suffer from a 'periphery discount' on returns (Steinle and Schiele, 2002). Although the literature is rich in explaining how clusters emerge, there are little, if any, examples of industrial policy being able to create a cluster when a first mover is already well established. Steinle and Shiele (2002) stress that a condition for the emergence of a cluster is the potential for network innovations that take place in a 'club membership' industrial context. Our findings from Kent reveal very high transaction costs and that potential suppliers know very little about current issues and technological development in the offshore wind energy sector, i.e. local firms are not 'part of the club'. This suggests that the conditions for the emergence of a UK wind energy cluster can only be described, at best, as unconvincing.

A counter-argument would be to argue that in many industries, commercial history has shown that first mover advantages could come at significant costs and firms preferring to wait and learn could benefit from second-mover or even follower advantage. Cottrell and Sick (2002) show that follower advantage is about exercising a real option to wait and learn when imitation will pay off more than a strategy of being first to market. The German and Scandinavian clusters however are not exposed to the type of technological uncertainty that would result in a waiting real option being 'in the money'. Instead, the key features of the industry are long value chains, multiple competencies, and network-level innovations: these reinforce the thesis that players with first mover advantages will be difficult to dislodge.

A Global Search Perspective

It is true that genuine supply chain issues are affecting the sector: for example the lack of capacity to match rapid growth in demand after the excess supply period of 2001-2004 is said to have led to rising prices for construction projects (Green and Vasilakos, 2009). In this context, it is legitimate that the country with the greatest consumption rate and that is contributing the most to demand stabilisation would advertise an economic opportunity. Demand conditions though are not a sufficient condition for the emergence of a cluster. In this context, imposing local content requirements may actually decrease the competitiveness of the sector and increase the cost of electricity. As discussed above, local content requirements/local supply chain concepts clash with supply chain management thinking. If an analogy is made with the airline/airplane manufacturing industries (who stand in the same relation than wind farms/wind turbine manufacturers do), today's policy in the wind energy sector amount to stating that the only way for British airlines to be competitive and to grow is to fly British-made aircrafts.

This confusion between the performance of the user and the capital good provider is compounded by ambiguity about the requisite level of analysis for policy making. Policy makers focus on the industry level, a macro level which is beyond the normal scope of supply chain thinking. Local wind farm operators discuss supply chain at an intra-organisational (micro) context which amounts to traditional purchasing and logistical management. This leaves more modern meso-levels (Leseure, 2010) unexplored as shown in figure 2. A lot of modern supply chain research is conducted at the inter-organisational level. Issues explored are collaboration between supply chain members and the design and operations of jointly owned inter-organisational systems. Examples of applications are demand chain management, managed inventory systems, etc. Inter-organisational supply chain research is equivalent to a local search for solutions in a space defined by existing network topology and designs and does not currently find application in a wind supply chain as neither information nor inventory management are issues in this industry.

Another conceptualisation of supply chains is at the meta-organisational level. In this perspective approach, a (possibly virtual) party is assumed to own or have enough control over the whole supply chain that it can design it from a global perspective, free of any historical design or practice. The search for solutions is a search in a global space. Research about supply chain design in operational research typically falls within this category. We propose that this modelling of supply chain is the most useful both for the UK wind energy sector case study and the study of sustainability within supply chain configurations.

A sustainability agenda requires a meta-organisational perspective in order to avoid the definition trap discussed in the previous section. In other words, policy makers need to shift their emphasis from a local search for solutions to a global search. This is illustrated in figure 3 which presents contrasting views of the offshore wind supply chain.

Figure 3 contrasts the UK policy view of the offshore wind supply chain (on the right hand side) with a genuine meta-organisational supply chain view on the left hand side (based on a supply chain being a multi-echelon inventory system). The offshore wind supply chain is unusual in that neither the input (wind) nor the output (electricity) can be stored: this makes for a rather exotic context of application of supply chain management theory, as questions of inventory management along the supply chain become meaningless. This is perhaps why UK policy has focused instead on the construction supply chain, a diagonal but more tangible supply chain. As discussed above, there are genuine supply chain issues to be addressed in the construction supply chain: the aim of this paper is not to criticise looking at it from a cost perspective (it does indeed represent the majority of the financial investment), but to argue that it is a mistake to reduce the offshore wind supply chain to it and to formulate policy only at this 'local' level. We argue that the scope of the search for value, competitiveness, and sustainability should be extended to the whole supply chain depicted on the left hand side of figure 3.

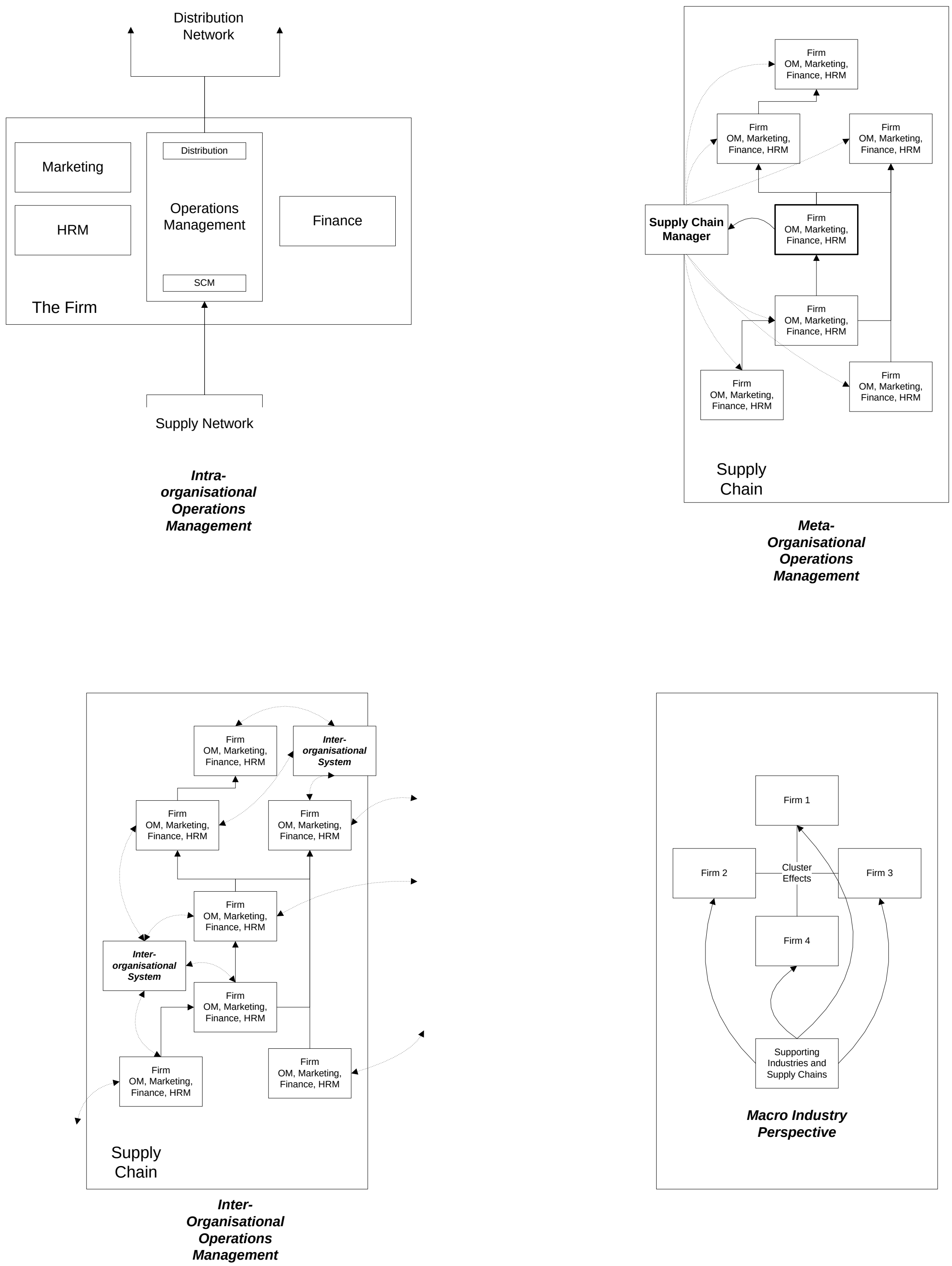

Figure 2 – Different level of analyses of supply chains (adapted from Leseure, 2010)

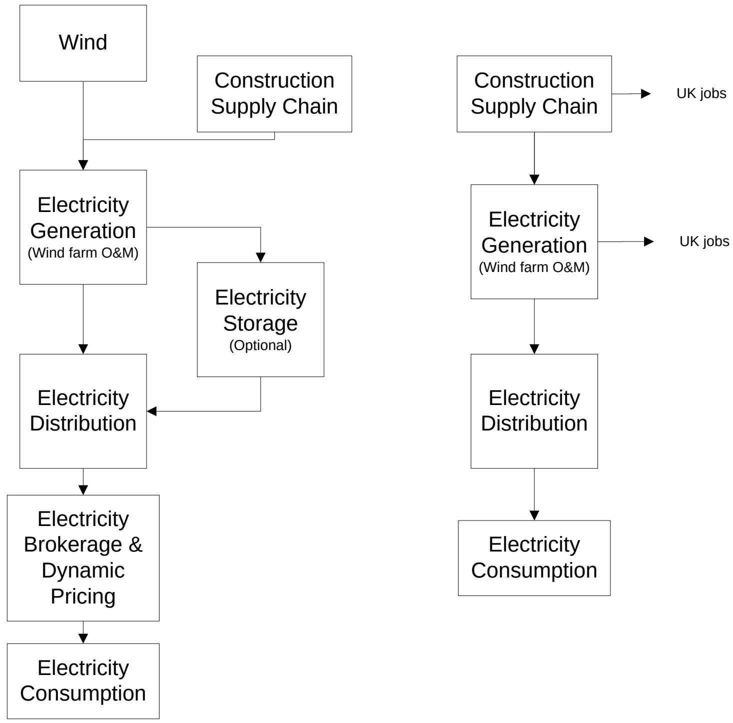

Figure 3 – Contrasting Views of the Offshore Wind Supply Chain

The ultimate objective of the UK offshore wind supply chain should guide the global search for better solutions. This ultimate objective should be the generation of sustainable electricity for consumers. As we are investigating UK policy making, it is sensible to set that the ultimate objective is to provide cheap, renewable energy to UK consumers.

In order to guarantee low cost of electricity for UK consumers it seems sensible to take advantage of existing wind turbine clusters in other parts of Europe rather than to compete with them and to incur the risk of 'periphery discounts' on returns. This would also contribute to the development of Europe as a wind energy cluster and strengthen wind energy exports.

A global search would encourage policy makers to look for other opportunities in order to create value and to innovate: this could be at any level shown in figure 3. This recommendation includes:

- investing is services surrounding the operations and maintenance of wind farms,
- relying on non-UK clusters for supply,
- seeking partnering opportunities with non-UK clusters as demand exceeds capacity,
- identifying 'new spaces' in the operations and maintenance domain through supply chain learning, with a view to gain 'club membership',
- investing in electricity storage solutions,
- looking for more effective electricity distribution arrangement (e.g. inter-connection between wind farms and between countries; Green and Sasilakos, 2009), and

- dynamic pricing and yield management. The competitiveness of the offshore wind sector is very dependent on capacity utilisation. Current load factors are typically 40% of wind farms' capacity. There are many industries that exhibit yield management challenges and many well tested operations management and pricing techniques which could transform the profitability of this sector. Examples include a retail spot market for electricity, coupled or not with 'intelligent homes' or 'responsible consumption programmes'. These are examples of a few potentially high value innovations which could be explored and that could have a significant impact of the competitiveness of the sector as well as on other forms of renewable energies.

Our argument is qualitative though and we accept that some of the underlying technologies (e.g. electricity storage) are still at an early stage of development and remain commercially unproven. The potential of the UK to became a centre of excellence in the supply chain downstream of electricity generation is however particularly promising given the size of the markets involved, the existence of adequate factor endowments and firm rivalry, and supporting industries. It would appear that in this downstream supply chain, conditions for the emergence of clusters could be met.

Conclusion

As a conclusion to our case study, we argue that policy makers should broaden the scope of their policy in order to make investments in wind energy that are truly sustainable for UK consumers. This include defining the wind energy supply chain more broadly, looking for sustainable economic opportunities throughout this extended supply chain, and seeking first-mover advantages through new clusters rather than by attempting to compete with new clusters.

In the general context of the academic discussion of the emerging concept of sustainable supply chains this case study illustrates the challenges with the process of framing sustainability and supports Ihlen's warning about sustainability rhetorics (2009) and self-serving processes of definition. Many operations systems make claims to sustainability by adopting definitions of sustainability that artificially limit or distort the level of analysis. In the case of the UK offshore wind industry our conclusion is that it is only by looking at the supply chain as a meta-organisational system that a claim to sustainability can be made and that appropriate policies can be formulated. Whether or not this conclusion can be generalised to all industries is an important research question in sustainable supply chain research. It implies that seeking sustainability within supply chains historical designs, or when constrained as a local search for sustainability, could lead to suboptimal solutions. Whereas supply chain research has been effective at the intra-organisational and inter-organisational level, we argue that sustainable supply chains are better researched at the meta-organisational level.

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