Together we share? Managing competitive and collaborative supplier interests in product development activities

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Introduction
In the literature on supplier involvement in product development activities, the role of mutual interests and shared incentives for collaboration is often stressed or implied. For instance, in highly dynamic and knowledge-intensive industries in particular, where product development activities are distributed because of the fragmentary stance of knowledge available and/or the knowledge base is constantly evolving, firms have common interests, since they compete on a value-network versus value-network basis rather than on a firm-to-firm basis (Normann and Ramirez, 1993). Thus, less attention has been paid to the potential rivalry between suppliers and how this influences the organization and management of collaboration activities in distributed product development settings. In business networks, roles and positions in the overall division of work are dynamic (Anderson et al., 1998). The strategic scope of actors involved in distributed product development activities evolves over time, in line both with the strategic decisions they make and with changes in the technological context of product development. This results in strategic tensions among actors with collaborative and competitive interests and impacts on the formalization of coordination and division of work in new product development activities.

This comparative case study concerns the organization and management of inter-firm product development activities in the Danish wind turbine industry. It compares how the organization and management of supplier involvement in product development activities is carried out in competitive and collaborative settings respectively. The paper starts with an overview of the literature on management and organization of interfirm product development activities. We then present an outline of the role and importance of supplier involvement in product development activities in the Danish wind turbine industry, illustrating this by means of our case studies. In the final part of the paper, we compare product development and management activities in competitive and collaborative distributed product development settings, and present three propositions regarding how supplier rivalry and technological specialization influences roles, coordination patterns and communication between actors in distributed product development projects. The paper ends with a discussion of managerial and academic implications and the limitations of our study.

Distributed product development activities and supplier involvement: Theoretical considerations
The importance of involving suppliers in product development activities is widely acknowledged in the literature on innovation management, and has been documented in various studies and in various industrial and country contexts (Christensen and Kristensen, 1994; Christensen et al., 2001; Roberts, 2001).

The role of suppliers as contributors to innovation has been strongly emphasised in the literature on innovation systems (Lundvall, 1993). Users and producers develop a shared technical language, which enables them to bridge the gap between user contexts and technological contexts. This supports relationship-building and closer interaction between suppliers and buyers (Kristensen, 1992). Furthermore, user-producer relationships may represent a cognitive division of work, which informs knowledge searches and innovativeness as each actor specializes in different aspects of knowledge development but collaborates on joining these insights in order to increase product or process performativity (Nooteboom, 2005). However, this line of literature mainly addresses the performance effects of collaborative innovation activities.
rather than the process of organizing and managing the involvement of suppliers in product development activities.

The literature includes a number of contributions dealing explicitly with supplier management (Croom, 2001; Holmen and Pedersen, 2003; Håkansson and Eriksson, 1993; Johnsen and Ford, 2000), which have identified a range of issues regarding supplier involvement in product development activities (Choi and Krause, 2006; Johnsen et al., 2006; Schiele, 2006; Wynstra and Pierck, 2000). Wynstra et al. (2001) present a framework of three main groups of management problems pertaining to supplier involvement. The first group are specifically related to the motives, interests and capabilities of the supplier. These concern both the selection and commitment of suppliers, and the development of suppliers’ collaborative and technological competencies in order to bring them into strategic and operational alignment with those of the manufacturer.

The second group of issues concerns the manufacturer, and include organizational problems such as organizational resistance and competence issues. Organizational resistance to suppliers’ involvement in product development activities can stem from internal R&D envy or from other departments’ anxiety about becoming redundant. Competence issues concern the lack of capabilities in managing supplier relationships, i.e. including employees with technical, commercial and social skills in an organizational unit and giving this both the authority and responsibility for interacting efficiently with suppliers. In a similar vein, Croom (2001) discusses the process of realizing the strategic importance of supplier relationships for product development and of integrating such concerns in the strategic agenda-forming process of the manufacturer. According to the strategic importance of supplier involvement, manufacturers may vary their organizational setup and commitment in the involvement process. Wynstra & Pierck (2000) suggest a supplier involvement portfolio based on two fundamental dimensions guiding the extent of manufacturers’ organizational and managerial commitment to the relationship in different product development contexts: One dimension concerns the degree of development responsibility of the supplier, ranging from full technical specifications to functional specifications where suppliers have the responsibility for developing a specific component. Another dimension concerns the manufacturer’s strategic risk regarding the component’s importance to the development (and manufacturing) of the finished product. This may be seen both in relation to output (i.e. product performance) and process (interaction with other component development tasks) issues.

Figure 1: The supplier involvement portfolio (Wynstra and Pierck, 2000)

<table>
<thead>
<tr>
<th>Degree of supplier’s development responsibility</th>
<th>High</th>
<th>Arm’s length development</th>
<th>Strategic development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>Routine development</td>
<td>Critical development</td>
</tr>
</tbody>
</table>

These dimensions reflect both the division of work and the required management of knowledge exchange. Strategic development requires the interaction of several management functions, including production, purchasing, R&D and marketing, on both sides of the manufacturer-supplier dyad. Here, there is no clear-cut division of work, so continuous mutual adaptation is needed, suggesting frequent face-to-face meetings and the setting up of joint development teams across organizational boundaries. In critical development, a high degree of pre-specification of component requirements decreases the need both for communication and the involvement of
multiple departments at both the manufacturer's and the supplier's. As regards arm's length development, the supplier has control over the development task within some pre-specified interfaces, which also limits the need for interaction and communication. Lastly, in the case of routine development, communication is more or less pre-programmed and involves suppliers' sales departments and the manufacturer's purchasing department respectively.

The third main group of management issues concerns the dyadic buyer-supplier relationship, including information exchange aspects (the ability to communicate involvement expectations clearly and involve all relevant parties from both the supplying and the buying organization) and trust aspects (which concern expectations of respective roles in product development activities and collaboration norms, e.g. regarding distributive justice and norms of reciprocity). With regard to information exchange, Croom (2001) uses the content (pre-programmed or ad hoc) and the focus (general at the relationship level or specific on critical issues) of information exchange to distinguish four different and complementary interaction channels. He suggests that general ad hoc information exchange in particular serves the purpose of building empathy among actors, hence supporting more programmed and specific forms of information exchange in product development. This view is supported by other and more general studies of communication in buyer-supplier relationships (Mohr et al., 1996).

With respect to interpartner-trust issues, the literature on the management of supplier involvement in product development activities is less clear. Trust can be defined as “the judgement one makes on the basis on one’s past interactions with others that they will seek to act in ways that favour one’s interests, rather than harm them” (Lorenz, 1999). Since supplier involvement in product development activities often creates a public good in terms of knowledge, which can be used (and abused) by the individual actors in other contexts, the issue of managing trust is clearly present. The innovator trying to access specialized capabilities through contracts with suppliers may encounter difficulties in inducing them to give costly irreversible commitments that are dependent on the success of his project, i.e. persuading suppliers to share the risk with the buyer (Teece, 1986). Furthermore, suppliers or buyers may have no clear agreement or ex ante understanding of the commercial possibilities involved when engaging in joint development efforts (Scarborough, 1995), and the supplier may therefore be tempted to “run with the technology” if the innovation is successful (Teece, 1986). Managing the involvement of several suppliers with overlapping, and even competing, capabilities and corresponding business scope is likely to have a considerable impact on the organization and management issues concerned. From a motivation point of view, manufacturers may benefit from creating a situation of innovation rivalry among suppliers, since this forces suppliers to dedicate more resources to the product development process and compete for positioning. Trust issues may relate to both the interfirm and the personal level (Andersen and Kumar, 2006). The lack, or deterioration, of interfirm trust can jeopardize innovation collaboration, as demonstrated in the case of Novo and Nissho (Andersen and Christensen, 2000), which showed that trust or lack thereof can seriously affect communication among buyers and suppliers collaborating on product development. This may make suppliers downplay their involvement in product development activities or withdraw from them altogether. In terms of managing such activities, the collision of interests among suppliers may influence the structuring of information exchange and other forms of collaboration. On a personal level, lack of experience in dealing with new partners, or distrust resulting from previous business relations, may also affect communication abilities negatively and lead to more structured patterns of communication (Andersen & Kumar, 2006).

**Distributed product development in the Danish wind turbine industry – a brief description of the industry context**

In order to understand the context in which supplier involvement in product development unfolds, a brief description of the roots and origins of the wind turbine industry is needed, together with an overview of the product and the collaboration tasks faced. The modern Danish wind turbine
industry has its roots in the oil crisis of the 1970s. The Danish wind turbine industry grew rapidly during its first decade, accounting for more than 80% of the world market in the late 1980s (Karnøe and Jørgensen, 1995). While the world market in the 1980s primarily consisted of Denmark and California, the emergence of new markets during the last two decades has meant that wind power is currently the fastest growing energy resource in the world. Currently Danish producers account for approximately 40% of the world market, with exports making up more than 90% of total sales. With wind energy generating approximately 20% of the electricity consumed in its home market, Denmark has been an important incubator for technological development, and remains important for innovation as a strategic and demanding market. Europe is currently the largest world market for wind power, followed by the US, but markets in Asia are growing rapidly.

The basic components of a wind turbine
The main components of a wind turbine are rotor and hydraulic systems, drive train and gear systems, electrical generator towers and yaw systems. Besides these main systems, there are also several additional systems, for fire prevention, maintenance, etc. A modern wind turbine, such as Vestas’ V90-3mV turbine, typically consists of more than 100,000 components. The rotors of modern wind turbines generally consist of three blades, the speed and power of which are usually controlled by pitch regulation. Rotor blades are manufactured from composite materials, sometimes in combination with wood and carbon, which give the entire rotor specific characteristics, affecting the load on the system, design of gears, main shafts, etc. Energy captured by the rotating blades is transferred to an electrical generator via a gearbox and drive train, or the generator is coupled directly to the rotor in a "direct drive" arrangement. Turbines are able to operate at varying speeds, a characteristic which improves compatibility with the electricity grid. The gearbox, generator and other control equipment are housed in a nacelle. Tubular towers supporting the nacelle and rotor are usually made of steel, and taper from the base to the top. The entire nacelle and rotor is designed to move round, or “yaw”, in order to face the prevailing wind.

Evolution of the wind turbine industry
It is generally agreed that the bottom-up approach of the Danish industry has been superior to the top-down approach of the wind turbine industry in the US in terms of achieving competitive results, based on innovation capabilities distributed among its actors (see, for example, Garud and Karnøe, 2003). The emergence of the modern Danish wind turbine industry is important to understanding the current practices of distributed product development activities. In 1972, a Danish carpenter, Christian Riisager, built a wind turbine in his back yard, which was the forerunner of the 72 wind turbines built over a 2-year period in the mid-1970s (Jensen, 2003). Heavily inspired by Riisager, the so-called ‘teacher group’ at Tvind, a controversial Danish private school community, set out to create the world’s largest windmill, ‘Tvindkraft’. In turn, this group of amateurs inspired several other pioneers in the Danish wind turbine industry (Jensen, 2003). The main actors in the early development of the industry either diversified into wind turbine production in response to stagnating markets in, for example, agricultural equipment, or were small do-it-yourself entrepreneurs. This was also the case for core subcontractors. For example, Vestas Wind Systems, which – following its acquisition of NEG Micon and Siemens’ acquisition of Bonus Energy – is the largest and only remaining Danish-owned wind turbine producer, was originally a forging shop, and LM Glasfiber - now the

1 The European Wind Energy Association; [www.ewea.org](http://www.ewea.org), Wind Energy Facts.

2 Vestas is considered a Danish-owned company despite only one of the three main shareholders being Danish (ATP, Denmark’s largest pension fund). The other two main shareholders are American (Franklin
world’s largest blade producer - was originally a producer of fish crates and sail boats. These were very hands-on firms, which, in the early years, carried out no formal R&D activities. Learning took place through practical experimentation, although more formal design and development functions did emerge gradually (Jensen, 2003; Karnøe, 1999). In particular, with the growing use of the Risø test station, a state supported R&D unit open for all producers and suppliers, knowledge on aeronautics and other aspects of applied physics were disseminated from leading research institutions to the practical field of wind turbine manufacturers and their suppliers. As a result of the hands-on approach and the state support issued by the Risø test station, from an early stage innovation in the Danish wind turbine industry was stepwise and distributed between actors, unlike US wind turbine manufacturers, who were large MNCs, with matching internal R&D budgets. These firms concentrated more on making radical technological breakthroughs, rather than building on and improving existing designs. As a consequence, research was secretive and driven by a top-down thinking (Karnøe, 1999). In comparison, the design and production of several components was carried out in a collaborative network, which, with its many SMEs and dedicated research institutions, meant that Danish wind turbine producers were able to benefit from the competencies of firms distributed across a range of suppliers in a connected network.

Along with the technological improvement of wind turbine designs generation of electricity from wind power became increasingly feasible. As energy generated from wind increasingly became price competitive with that of fossil fuels, two important and interrelated events occurred, which have strongly affected the competitive conditions of wind turbine manufacturers and which, in turn, may have a huge impact on current procedures for collaboration and knowledge sharing. These are the liberalization of the electricity market and the entry of resourceful MNCs into the industry.

Liberalization of the European electricity market was initiated by the UK in 1989, and, in 1997, EU Ministers agreed on a directive for liberalization in Europe. This has resulted in a shift in buyers: from individuals and wind power cooperatives to larger investors and developers investing in and building wind energy power plants. The success of the developers’ business models depends on their ability to ensure a viable payback to investors. As a consequence, they are chiefly interested in the revenues and operating costs of wind power plants. The technological efficiency of wind power turbines is only one aspect of this complex equation, which means that the development and manufacturing of wind turbines is, to a much greater extent than previously, driven by market demands for cost efficiency.

One consequence of the rapidly expanding market for wind energy is that new global competitors, such as GE Wind and Siemens, are entering the industry. In addition, Vestas, now the largest turbine producer in the world, has grown considerably through its acquisition of NEG Micon, a Danish competitor, in 2004, marking the latest step in a series of rationalizations, buyouts and mergers in the Danish wind turbine industry.

Together, the liberalization of the market for green energy and the increasing competitive pressure from the resourceful global competitors has strengthened the importance of innovation as a competitive parameter among producers. The industry is under strong pressure to develop basic as well as applied technologies. Technological improvements have been made in three main areas:

- **Supporting the reliability of wind power technology as an energy resource by drastically increasing the uptimes for wind turbines.** In the early days of wind power at the beginning of the 1980s, turbines were often down for repair more than they were in operation. Today, manufacturers’ availability data show that wind turbines have, on
average, an uptime of more than 97% over the 20 years of their lifetime (EWEA, 2005). Distributed product development activities involving suppliers have played a crucial role in refining technological knowledge on how to reduce mechanical stress and improve reliability and in introducing new components and materials.

- **Improving the energy production capacity of wind turbines**, achieved through the development and mass production of larger and more energy-efficient turbines. In 1980, a wind turbine with a rotor diameter of 15 metres would produce 50 kW of energy. In 2006, the largest mass produced wind turbines have a rotor diameter of 124 metres and produce 5000 kW of energy, and even larger wind turbines are under development. Over the past 20 years, approximately 10 main designs of wind turbines have been marketed by the leading players in the industry, each of them in dozens of variants, depending on use conditions. The increasing energy efficiency of wind turbines is not simply achieved by scaling up wind turbines in size. Increasing sizes calls for different technologies. For instance, the tower of a 5000 kW wind turbine is more than 100 metres high, and is subject to extreme mechanical pressures compared with a 50 kW wind turbine with an average height of 25 metres, which was the standard 20 years ago. This requires new ways of thinking and greater specialization in technologies for resisting strong wind pressures and extreme weather conditions. This technological development has also been strongly contingent on user-producer interactions between suppliers of components and services and main contractors. Based on their knowledge from complementary industries, e.g. agricultural machinery and shipbuilding, suppliers have been able to make significant contributions to wind turbine development projects.

- **Increasing the scope and variety of user contexts**. In step with the development of a global market for wind turbines, the variety of possible locations has increased dramatically. Wind turbines have therefore been adapted to operate under extreme temperature conditions, in areas with very low or very high humidity, on land as well as offshore, and in connection with each other, forming so-called wind power plants. The increased scope and variety of user contexts has called for stepwise product development activities in order to modify or rebuild wind turbines to work under extremely different operational conditions. Product development inputs from suppliers have played a strong role in such efforts.

As shown above, suppliers to wind turbine manufacturers are heavily involved in distributed product development activities, not only in the process of developing prototypes, but also directly involved in the development of components, and in the testing and ongoing modification of new wind turbine designs. As no producers holds all knowledge aspects necessary for developing a new wind turbine design in its totality, nor master the complex process of managing these activities internally product development efforts call for distributed and joint collaboration among manufacturers and suppliers. As described by Anders Allesø, project engineer at Nissens, a producer of coolers:

> Wind turbine manufactures such as Vestas want us to collaborate on technology design. They may have some initial requests, but the process of translating these into product specifications is a joint process...internally in Vestas this is known as a TPS - a technical product specification.

**Methodology**

Given the explorative nature of this research and the corresponding need for deep insights into the nature of supplier involvement in complex organizational settings, the empirical part of the paper is based on a qualitative case study methodology (Yin, 1994). A case study approach is recommended when the issues are complex and evolving, and where alternating between the
empirical field and different theoretical frameworks can be useful for generating additional insights (Orton, 1997; Yin, 1994).

Numerous informal talks with managers at business or research seminars have also provided important background information. Interviews with one or several company representatives responsible for product development activities, typically development engineers and technical or division managers, have been carried out in the investigated companies. The interviews were conducted using a semi-structured interview guide, thus resembling more of a dialogue than a questionnaire-based interview. The interviews have been recorded and transcribed. In addition, various sources of information have been collected, including newspaper clippings and internal material. An overview of the investigated companies is shown in Table 1.

Table 1: Key data on the case firms

<table>
<thead>
<tr>
<th></th>
<th>Hydac</th>
<th>Vestas Wind Systems</th>
<th>Nissens</th>
<th>EM Fiberglas</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of employees</td>
<td>4000 (worldwide)</td>
<td>9600</td>
<td>830</td>
<td>150</td>
</tr>
<tr>
<td>25 (Denmark)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year founded</td>
<td>1963 (Germany)</td>
<td>1945</td>
<td>1921</td>
<td>1966</td>
</tr>
<tr>
<td>2000 (Denmark)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of entry into the wind turbine industry</td>
<td>1996 (Germany)</td>
<td>1978</td>
<td>1995</td>
<td>1980</td>
</tr>
<tr>
<td></td>
<td>2000 (Denmark)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turnover, DKK mill.</td>
<td>4,500 (10%)</td>
<td>19,200 (100%)</td>
<td>700 (8%)</td>
<td>N.A. (70%)</td>
</tr>
<tr>
<td>(% related to wind)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development activities related to wind turbines</td>
<td>Partnering with customers on development of wind turbine cooling and hydraulic systems</td>
<td>End producer, i.e. all areas of wind turbine manufacturing</td>
<td>Components for cooling solutions</td>
<td>Various fibreglass components for turbines, e.g. nacelle cabins.</td>
</tr>
<tr>
<td>Other areas of activity (non- wind related)</td>
<td>General Industry, Mobil, Marine, Mining technology and Process industries</td>
<td>None</td>
<td>Radiators for the automotive industry, coolers for industrial use</td>
<td>Sanitary equipment, parts for the train and automobile industry, coverings for sewage disposal plants</td>
</tr>
<tr>
<td>Persons interviewed</td>
<td>Mark Stig Berg, Wind Power Manager</td>
<td>Poul Sperhage Frøkjær, Dennis Højer Sinnbeck, René Mikkelsen, development engineers</td>
<td>Hans Erik Ob ling, general manager Anders Allesø, project engineer Stig Jochum sen, sales manager</td>
<td>Poul Christensen, production engineer</td>
</tr>
</tbody>
</table>
Vestas is the world’s largest manufacturer of wind turbines, with an estimated world market share of around 29% in 2005. Nissens has been involved in the wind turbine industry for more than 15 years, and their customers include all large Danish manufacturers and a number of foreign manufacturers. Hydac in Denmark is a division of a German-based company. The company has served the global wind turbine industry for more than 10 years, and has established a sales and engineering subsidiary in Denmark, which collaborates closely with the German headquarters. EM Fiberglas is a medium-sized supplier of customized fibre glass components, which, among other things, has been involved in producing coverings for wind turbines since the early 1980s.

Case studies
The case studies concern two examples of distributed product development activities, one involving component development for product adaptation efforts (case A), and the other involving component development for a new generation of wind turbines (case B).

Vestas Wind Systems (henceforth Vestas) is the main contractor in both of the investigated cases, although two different teams of engineers in different departments are involved in case A and B respectively. Nissens’ OEM Division (henceforth Nissens) is involved as a supplier of cooling technology and components in both cases. In case A, the adaptation of a V52 wind turbine for special weather conditions in Dubai, Nissens acts as the main component innovation architect, designing and constructing the cooler used. Nissens has collaborated on this together with Vestas’ engineers and EM Fiberglas, a supplier of fibreglass components. In the second case, involving the development of a new and larger wind turbine, the V120-4.5 MW, Vestas brought in Nissens as sub-supplier to a component development task headed by Hydac, one of Nissens’ strongest rivals in the market for coolers.

The projects analysed in the two case studies take place under different conditions. The development project described in case A was initiated in 2003, prior to the merger between Vestas and NEG Micon in 2004, while the project described in case B was initiated after the merger. Following the merger, Vestas sent out enquiries to all its suppliers for the purpose of selecting preferred suppliers based on competing bids. As a result of this process Nissens was selected as a preferred supplier of coolers for a 3-year period. Furthermore, problems with the quality of supplies, leading to component breakdowns in installed wind turbines, led Vestas to emphasize supplier responsibility in the form of more explicit and codified production standards in the contracts. Through these measures, supplier involvement and responsibility became more formalised.

Case A: developing a cooling system for Vestas’ V52-850 kW wind turbine
In 2003, Vestas received an enquiry about a V52-850 kW turbine - one of the company’s best-selling turbines ever - from Abu Dhabi, an oil-rich sheikdom and capital of the United Arab Emirates. The use of wind turbines has been very limited in this region, and Vestas saw the project as an opportunity to learn about operational conditions in the region while at the same time establishing a showcase for a turbine that area-based forecasts predicted would have large sales potential.

The operational conditions of the turbine were a critical issue. The mechanical load on wind turbines is very strong, and getting rid of the heat accumulating in the nacelle during power production is important for ensuring the long life of the turbine, since excessive heat can damage the electronics and other heat-sensitive components and materials. In Abu Dhabi, the months June - September are very hot, with temperatures averaging above 40°C (104°F). However, the standard V52-850 kW turbine stops operating at 40°C. The newly developed V52-850 kW HT is designed to operate in the ambient temperature range of -20°C to +45°C (-2°F to +113°F) (Vestas, 2005). Because of the development potential, Vestas gave the heat management issue high priority. The project required non-standard components that Vestas could not provide
internally, so it was decided to include two existing primary suppliers in the development effort: Nissens, a supplier of coolers; and EM Fiberglas, a supplier of coverings, etc.

Organization and management of the V52-850 kW HT development project

Vestas has an explicit management approach towards supplier involvement in both new product development and modification activities, which was also followed in this case. Vestas uses a Stage-Gate project model for organizing integrated product development, which means that all relevant departments in the company are actively involved in development projects. In the V52-850 kW HT project, employees from the purchasing, engineering, and service departments were among those involved. After deciding on the overall technical specifications, Vestas forms the project group. In addition to scheduling the job and drawing up a budget for approval by the Gate Review and Steering Groups, the job of this project group is to develop an initial project architecture, which includes identifying development tasks and inviting product development contributions from so-called primary suppliers, i.e. suppliers the company has confidence in. Nissens has developed and produced a range of cooling devices for different generations of Vestas turbines – in most cases as the only supplier of coolers. According to Vestas, more than 90% of the coolers in their turbines are supplied by Nissens. EM Fiberglas has been a supplier for NEG Micon (which merged with Vestas in 2004) since the early 1980s. EM Fiberglas primarily supplies coverings.

As a guide to suppliers, Vestas provides the functional specifications of the turbine, which both results in early input for Vestas and helps suppliers assess their interest in and adequacy of their skills for the development effort. In the wind turbine industry, it is quite customary for suppliers to regard initial product development contributions as part of their marketing activities. Often, suppliers do not receive any payment for their product development contributions, but they expect these contributions to increase their chances of becoming primary suppliers when the turbine enters production. In this sense, wind turbine manufacturers use a risk-sharing partnership model. This is possible because the strong growth in demand for turbines makes it an attractive proposition for a wide range of suppliers. In this specific case, however, Vestas paid for Nissens’ development activities because the company had project development responsibility. Anders Allesø, development engineer at Nissens, recalls the situation:

Due to time pressures Vestas realised that they did not have the internal resources to run the project. They came to us and said: “we need a water cooler out of the Nacelle. It must be made larger because it is hot, therefore it must be mounted on the outside”. […] They said: “you make sure that it gets a cover and looks right, you ensure the sound reduction, and all that. What will this cost us? Subsequently we will buy the coolers from you and the fibreglass from the supplier we agree on using”. We looked at it […] and then we carried it through from start to finish.

 Although Nissens is in charge of project management, it was Vestas who contacted the other supplier, EM Fiberglas, and arranged the initial meeting with both suppliers. Communication between Vestas, Nissens and EM Fiberglas was open and frequent. Several meetings were held, supplemented with telephone calls, regarding technical principles, designs, tests, feedback from product development board meetings, etc. The meetings primarily took place at Nissens, but also at Vestas’ facilities in Ringkøbing and their test facilities in Viborg – in particular when the development efforts of this team needed to be coordinated with that of others. Participants from all organizations recall these meetings as being open and constructive, and where knowledge was also shared between the suppliers. Anders Allesø, production engineer at Nissens, describes the knowledge sharing/learning taking place between Nissens and EM Fiberglas:

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3 This has been stressed in several of our interviews – both by Vestas’ engineers and the suppliers.
If they [EM Fiberglas] learn something about coolers that they can use in another setting – fine with me! And we learn something about fibreglass and the available tools. It’s always good to learn something new, but it isn’t something I can use to oust EM Fiberglas, I don’t know enough about their product to do that. So in a case like that knowledge sharing is great.

Since there are too many unknown effects and interfaces, design feedback loops are necessary. For example, the first test assembly revealed problems with noise reduction, and there were also problems with air intake in the initial stages. Alterations were therefore necessary after the first test assembly. Due to the complexity and integrated character of a wind turbine, ground testing of a single component or system must be supplemented with on-the-spot testing using a full-scale production model. Dennis Høyer Sinnbeck, development engineer at Vestas, describes the uncertainty associated with this process:

You think that you can do a lot on the ground when all the relevant people are gathered, but there are just some things that you cannot do, things you cannot foresee.

In the current project, the test installation revealed problems with repairs and servicing. Both the nacelle and the extra cooling system, which was placed on the outside of the nacelle, must be accessible for servicing after the turbine is installed. This means that it must be possible to open both the nacelle cabin and the cover of the external cooling system. There is limited space on a nacelle, however, and the test installation on the turbine revealed that it was not possible to safely access the interior of the cooler. This meant that the design had to be changed.

Today, a prototype of the V52-850 kW HT turbine is in operation in Abu Dhabi, and - since it is a prototype – it is still closely monitored by Vestas. However, despite the knowledge generated from the project and the prototype being used as a showcase in various marketing contexts, the modified wind turbine has not led to any major sales breakthrough in the Middle East market.

Case B: Developing a cooling system for a new generation of wind turbines
The second case concerns the development of a cooling system for the Vestas V120-4.5 MW turbine, which represents a new generation of turbines. The development of each new turbine generation is extremely complex, since little can be used from previous designs. The greater the size and energy efficiency of the turbines, the greater the mechanical loads they are subjected to, which means that most of the turbine must be redesigned for each new generation. In consequence, only few design aspects from previous generations can be reused, emphasizing the need for external knowledge inputs from suppliers.

Poul Sørhage Frøkjær, originally from NEG Micon, but now development engineer at Vestas after the merger, explains that they brought in Hydac, a producer of cooling systems, among other things, relatively early in the project. This was both because of previous collaboration with the company and because choices between some basic concepts had to be made early in the process. Poul Sørhage Frøkjær describes the relation with Hydac as follows:

Hydac was a supplier for NEG Micon, which is now part of Vestas. They have been a supplier for 7-8 years, and as far as I know there has not been any serious controversy with them. Hydac is very forward looking in their supplies. They demonstrate that they will not be marking time, or increase prices to an unreasonable level, or what else you can do to reduce your supplies. In that way you can say that we trusted Hydac, but of course this did not mean that we did not enter a legal contract with them.
Hydac was also involved in other aspects of the project. Mark Stig Berg, Hydac’s sales and development engineer, who had previously worked as a consultant for NEG Micon, also designed the cooling system, working with performance specifications and suggesting a solution for the cooling problems of the new turbine with some clever new details. Mark Stig Berg describes it the following way:

*I got wind of Vestas’ plans about developing the V120-4.5 MW turbine. We delivered a pump and water station for the previous type, the 110, but oil tanks, etc., were supplied by others. But in this project we went for presenting Poul Frøkjær with a broad solution. Actually, he is an old colleague from NEG Micon [...]*. I tried to make it easy for Poul and suggested that we [Hydac] developed a system solution for Poul to look at and ask for revisions of. Poul liked the idea, but he did not give the go-ahead in the beginning, because he did not want to be locked-in by one supplier at such an early stage of the project. [...] But I went home and made an overall design of the cooling system – we could not just copy the old one.

Although Hydac also produces coolers, and is considered to be a main competitor of Nissens, Vestas included Nissens in the project. This partly because Vestas had chosen Nissens as its preferred supplier of coolers a few months before the project started. This was a tricky situation for all partners. So while Hydac could have supplied the coolers for the entire cooling system, out of respect for the agreement between Vestas and Nissens, they decided to participate in the project without trying to persuade Vestas to choose between the two suppliers. Mark Stig Berg, Hydac, explains:

*This project was so large, there was so much more in it, so we decided to do it. We discussed it a lot internally, whether it was sensible - also with the owner in Germany. [...] We decided to aim for success with all the other parts of the system, and not waste energy on getting our coolers in, since it could go wrong. And after we decided that the best solution was to let Nissens get the coolers, we could just as well try to make it a successful collaboration.*

Nissens was somewhat uncomfortable with the situation at the beginning, because they saw Hydac as their main competitor. Whereas Nissens only produces coolers, Hydac makes a wide range of products, including oil tanks, filters, accumulators, etc. Anders Allesø, Nissens, saw the situation as follows:

*Sudden we get a request from Mark that he needs cooler parts for the new Vestas turbine. This was a few months after we had been engaged in a fierce competition. This was a little strange. [...] We were told by Vestas that we were still their preferred supplier, but now it was Mark who was responsible for the development, he was running the project and was Vestas’ right hand. We had an internal discussion, and I was not completely comfortable in the beginning. [...] We carry out calculations and counselling, and share our know-how with Vestas, and now we should do this with Hydac, and make sure that all things were considered. That was a little odd.*

Nissens’ management realized that it was former employees from NEG Micon who were responsible for developing the cooling system in Vestas, and that these people had more experience working with Hydac than with Nissens. So Nissens decided to accept the situation. However, in order to reduce potential collaboration problems, Nissan requested that all three parties were present at technical meetings. Furthermore, neither Nissens nor Hydac demanded
alterations to each other’s components, but the two companies adjusted their solutions to fit with the contributions of the other parties.

Vestas was also aware that the project constellation was unusual. While Poul Spærhage Frøkjær, Vestas, describes Nissens as a trusted supplier, in the present case less knowledge has been shared with Nissens than with Hydac:

*I have acted as if we did not have an agreement with Nissens [about knowledge sharing/non-disclosure]. In those parts of the deal, where it starts to get tricky, Nissens were not acquainted with the details. They have had an overall understanding about how things work, but not in detail, not where the technology was new.*

Vestas’ rationale for limiting the information flow to Nissens was to reduce the risk of spill over. This is not because Vestas distrusts the supplier – as described above, both Nissens and Hydac are trusted – but the company knows that its suppliers always want to provide the best solution for their customers, and will therefore use the experience gained from joint projects with Vestas when providing solutions for other wind turbine manufacturers. Likewise, Vestas benefits from the experiences that the suppliers have gained from working with Vestas’ competitors. But in an effort to minimize risks, Vestas involves as few suppliers as possible in critical development activities, and shares only the most necessary knowledge with them.

**Organization and management of the development project**

With regard to the organization and management of the development project, there were two different levels of interaction. Hydac and Vestas met in order to discuss matters of a more strategic nature – also involving other development teams, where Nissens was not included. At these meetings, Vestas used Hydac’s knowledge on cooling components. Nissens participated in the technical meetings, after the decisions about the overall design had been made. Nissens was therefore only brought in after Hydac and Vestas had agreed on the overall technological solution for the cooling system. As a result, Nissens insisted on the above-mentioned tripartite technical meetings. Poul Spærhage Frøkjær, Vestas:

*As I recall our meetings, Mark Stig [Hydac] was at the white board drawing a model, and Anders Allesø [Nissens] feeding him with calculations based on a computer model on his lap top.*

These tripartite meetings were used for exchanging technical specifications and adjustments rather than open discussions on potential technological developments. Technical details such as pump capacities, system pressure losses, etc., were compared and adjustments made. However, there was no, or very limited, interaction across the technological territories of the respective suppliers. In those cases where mutual adjustments between Nissens’ cooler and the remaining part of the system were necessary, Vestas would act as mediator. At meetings, Hydac would provide specifications regarding the temperature inflow, and, based on a software program, Nissens would immediately calculate the consequences for the dimensioning of the components.

Later on, as the project progressed from development to prototyping, Hydac built a mock-up of the system. For this they needed inputs from Nissens, which were provided in the form of detailed specifications on various performance issues. Nissens was not directly involved in the process. Mark Stig Berg explains that Hydac did not specify any tests on Nissens coolers:

*They were simply responsible for the cooler providing the effect that the three of us had agreed upon.*

This did not mean that Hydac had no reservations, however. Mark Stig Berg:
Of course, Nissens became acquainted with our neat idea, and they can use that in other circumstances. That’s the risk we took.

The rivalry and mutual respect between the two suppliers is echoed by Hans Erik Obling from Nissens:

We have the deepest respect for Hydac and their ability to deliver a competent service. In my view they are Nissens’ only real competitor.

The V120-4.5 kW was originally developed for offshore use. However, since the onshore market is currently perceived to be potentially more lucrative, Vestas has decided to focus resources on onshore activities and temporarily postpone the production of the V120 turbine.

Case analysis and discussion
The organization and management of supplier involvement in product development activities raise a number of issues, which are summarized in table 2 and further discussed below. These are divided into context factors, relating to the similarities and differences in organizational and strategic contexts of supplier involvement, and process factors, which relate to the organization and management of supplier involvement in the two cases studied.

<table>
<thead>
<tr>
<th>Analytical Dimensions</th>
<th>Case A: V52-850 kW HT</th>
<th>Case B: V120-4.5 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic risk involved for manufacturer and supplier</td>
<td>Medium risk for both Vestas, Nissens and EM Fiberglas</td>
<td>High risk, especially for Nissens and Vestas (Hydac had more to gain and less to lose than the other two parties)</td>
</tr>
<tr>
<td>Complementarities of interests and openness among involved actors</td>
<td>Extensive prior experience among actors (at both firm and personal level) and strong confidence among actors in partners’ intentions and capabilities.</td>
<td>Mixed prior experience at company and personal level. Limited openness among actors involved in the Nissens-Hydac dyad and the Nissens-Vestas dyad; relatively high degree of openness among actors in the Hydac-Vestas dyad.</td>
</tr>
<tr>
<td>Manufacturer issues (in Vestas)</td>
<td>Limited organizational complexity and complementary intraorganizational interests</td>
<td>Considerable complexity and somewhat conflicting departmental interests</td>
</tr>
<tr>
<td>Supplier issues</td>
<td>Nissens and EM Fiberglas: well-defined match between project demands related to critical development tasks, supplier capabilities and supplier strategies.</td>
<td>Hydac: well-defined match between project demands related to strategic development tasks, supplier capabilities and supplier strategies. Nissens: Mismatch between project demands and supplier strategies.</td>
</tr>
<tr>
<td>Development responsibility</td>
<td>Nissens and Vestas</td>
<td>Hydac and Vestas</td>
</tr>
</tbody>
</table>
### Coordination of Product Development Work

- **Mutual interaction and frequent meetings. Open dialogue between all three partners and dyads, including shared tests.**
- **Pre-programmed strategic meetings with set agendas involving selected partners, and technical meetings involving all three partners. Tests conducted by Hydac and by Nissens individually before combining in mock-up.**

### Division of Product Development Work

- **Shared division of work and fluid technology focus.**
- **Strong division of work and separate technology focus in the case of Nissens’ relationships with others, and interactive and joint division of work between Vestas and Hydac.**

### Knowledge-sharing and Communication

- **One level of knowledge-sharing and interaction only. Development of shared knowledge and information among all actors.**
- **Two levels of knowledge-sharing and interaction in function. Development of shared knowledge between Hydac and Vestas, but exclusion of Nissens in strategic and overall design phase; information-sharing among all partners on a need-to-know basis.**

Beginning with the process factors, there are important differences between the two cases in the division of product development work and in the way it is coordinated. In case A, although Nissens has chief responsibility for coordinating activities and delegating roles, there is considerable interaction between Nissens and Vestas as the designs co-evolve, suggesting what (Wynstra and Pierck, 2000) describe as the critical development model with a low degree of supplier development responsibility. In case B, collaboration between Hydac and Vestas is closer to a strategic development model (ibid.), characterised by a high development risk and a high degree of supplier responsibility for the development, although the final responsibility for what is included in the solution remains with Vestas.

The coordination of product development work in case A reflects a process of shared division of work (Andersen and Christensen, 2000), where the division of responsibilities and the coordination of work is subject to processes of collaboration rather than principles of hierarchy. Solutions to the heating and nacelle design problems are considered from both EM Fiberglas’ and Nissens’ perspective, with frequent meetings. Furthermore, in the prototyping phase, coordination is achieved through joint testing and ongoing mutual adaptation. In case B, interpartner meetings are few and there is a much clearer coordination structure, with few and programmed meetings, strongly focused on specific technical issues. There is some discussion and joint development efforts between Hydac and Vestas regarding the selection of an initial technological solution; however, this coordination scheme does not involve Nissens, who is only included when there is a pre-decided plan with a set agenda. In general, there are far fewer meetings between partners in case B, since most of the product development work is carried out by Hydac, with limited interference from Vestas and Nissens. Based on these findings we propose that:

**Proposition 1:** In product development projects involving multiple suppliers, supplier rivalry increases the formal division of work and formalizes the coordination patterns selected by manufacturers.
Reflecting the division of work and coordination patterns, knowledge-sharing and communication also differs between the two cases. In case A, the joint development of knowledge is an outcome of the collaboration, and there are few (if any) restrictions on knowledge-sharing. In case B, although the joint development of knowledge is limited, there is a lot of private knowledge development, not least in the case of Hydac, but possibly also (unintended) in the case of Nissens. Contractual restrictions stop suppliers from sharing knowledge with others, which results in a more strategic, but also more focused and programmed, form of communication. In this context, information-sharing is limited in richness but focused in scope. Therefore we propose that:

**Proposition 2:** In product development projects involving multiple suppliers, supplier rivalry increase the focus and programming of communication and decreases interaction intensity.

The two cases reflect two product development projects involving competitive and collaborative interests of suppliers respectively, which have clearly affected the structuring and division of work. This is predominantly reflected in the mixed degree of both personal and organizational relations and openness among the parties involved. In case B, there is very limited openness between Hydac and Nissens. In the case of the triad Hydac-Nissens-Vestas, the complexity of Vestas’ organisation influences the set-up of the project: Nissens becomes involved in the project through a contract between Vestas’ purchasing department and Nissens, while Hydac becomes involved as a result of the prior experiences and personal relations between former NEG Micon development engineers at Vestas. The mixed degree of prior knowledge in actor dyads seems to have had a negative influence on overall openness among the actors involved in the project.

However, besides rivalry and restrictions on knowledge-sharing, other contextual factors influencing project collaboration differ substantially as well, which also helps us understand the different managerial regimes of supplier involvement in the two cases studied. In case A, the development task is of medium importance only; although it concerns an important market expansion issue, it is something that Vestas is frequently faced with and involves the modification of a limited group of subcomponents in a wind turbine. Consequently, the risk issues involved are manageable. In case B, on the other hand, the development of a new turbine is extremely costly and complex, and is perceived by management as directly affecting the future strategy of Vestas. It involves a new turbine design and affects the fundamental technology architecture, since constructing a larger turbine is not just a question of upping the scale.

Nissens has defined itself as a supplier of cooling components, whereas Hydac perceives itself as a systems-based supplier, an integrator as well as a component provider. For this reason Hydac is better positioned for taking on increasingly specialized development tasks in strategically important innovation regimes, where manufacturers rely on system-based supplies. Realizing this, Nissens is now reconsidering its role as a component supplier. Stig Jochumsen, sales manager at Nissens, says:

> Until now is has been our strategy to be a component supplier, and not a system supplier. But we are discussing whether this is the right strategy. I think it has a lot to do with who the customers are. Some of the wind turbine manufacturers have a very strong engineering department; they want to know it all internally. In relation to them it is a good thing to be a component supplier. […] Others have engineers that do not understand all the components and they say: “I will find a collaboration partner who can offer me the whole package”. As far as I can see there are these two factions.

In the present case, Nissens’ profile did not match the Vestas development team’s requirements. An interesting point in this respect concerns the technological development
trajectory of wind turbines. Technological development in industries generally moves from a fluid phase towards an increasing degree of specialization and maturity (Utterback, 1994). The technological trajectory can be expected to influence both the business scope of and rivalry between suppliers. In the fluid phase of a technological evolution, technologies are at an incipient stage, where no high degree of specialization is either present or demanded, suggesting few, if any, entry barriers to the industry (Utterback, 1994). General-purpose component suppliers may enjoy a competitive advantage from their simultaneous presence in multiple industries. This presence gives them both economies of scope advantages, in terms of being less dependent on one specific industry, as well as enabling them to imitate and apply technological solutions from related industries without incurring strong cost penalties from adaptation. Moreover, in the fluid phase of technological development, where no one technological design is dominant, the lack of specialization makes it easier to contribute to several competing technologies at the same time. However, new capabilities are required as technologies move from the fluid to the transition phase, since, in this phase, manufacturers are faced with the challenge of serving a growing market demand. This can be illustrated by the fact that, although components for the first generations of wind turbines were taken from other industries (e.g. the gears were the same as the ones used in shipbuilding, or a modified type of gear used in sewage treatment), now components have to be designed specifically. As a consequence, suppliers’ involvement in developing process innovation capabilities becomes increasingly important. This overall change in the technological regime influences the manufacturers’ supplier selection criteria. Besides innovation competence, manufacturers increasingly require production management and logistic abilities, which are typically found in larger and more specialized suppliers. In relation to this, suppliers’ ability to take responsibility for larger and more complex parts of product development activities is also important. Nissens’ perception of two main types of customers may reflect the fact that the industry is currently in a transition phase. Based on this, we propose that:

**Proposition 3:** Deepening specialization of technological solutions affects component and system suppliers in different ways, giving the latter a strategic advantage over the former.

Another contingency factor concerns the organizational situation of the manufacturer, as also suggested by (Wynstra et al., 2001). In case A, only a relatively small proportion of Vestas’ organization was involved; whereas case B involved a large and diverse range of organizational departments with partly overlapping and partly conflicting interests. The merger between NEG Micon and Vestas not only added to the organizational complexity and turmoil, but the new supplier policy following the merger limited the choice of supplier and extent of supplier involvement. That different units and individuals within a company may have diverging interests and criteria with respect to supplier selection has been acknowledged by previous research on supplier selection and management (Webster and Wind, 1972).

**Implications**

Even though the two case studies analysed above involve suppliers who supplement each other in the one case and are direct competitors in the other, this is not a story about how distrust and fear of dishonest behaviour prevails among competitors trying to collaborate. On the contrary, all parties in the project involving competing suppliers express professional respect for their counterparts, just as they trust that they will live up to the agreements concerned. But the competitive situation nonetheless influences the degree of openness between the project partners and sets limits for the way in which collaboration is organised. The issue of trust cannot be completely ignored, however, since prior personal relations between various actors in the companies may play a role for the extent of responsibility delegated from a manufacturer to a supplier.
Understanding the context of collaboration is important for customers and suppliers involved in development project with contributions from multiple suppliers. For the project-owning customer, it is important to understand how relations between suppliers influence both the way collaboration is organized, the need for coordination and formal planning.

Suppliers, on the other hand, need to be aware that context influences their strategic possibilities. Furthermore, there may be different contextual dimensions: one relates to the individual companies, as exemplified by the context shaped by the merger between Vestas and NEG Micon. Another dimension can be labelled “mega-context”, and refer to the market and technological context, as exemplified by the wind turbine industry’s evolution towards a transition phase that gradually influences the supplier competencies required.

Our findings imply that supplier rivalry can have an impact on several dimensions as suppliers jockey for position with respect to servicing a particularly important customer. Moreover, their interaction reflects underlying agendas with respect to knowledge capture that may support or harm their strategic positioning in future exchanges. Further investigation of these issues may not only help unravel the dynamics of supplier involvement in particular, but also provide more general insights into the dynamics of interfirm collaboration.

Limitations
This study presents findings from a particular industrial context of supplier involvement. We realize that that there is a trade off between insights gained from an in-depth study of particular circumstances in an undocumented area and concerns of external validity of our findings. More studies are needed in other contexts in order to make our conclusions more robust and perhaps also more nuanced, through the inclusion of intermediating variables. Nevertheless, we believe that our study sheds light on an issue which is seldom studied, since suppliers are often secretive and do not allow investigations into collaborative rivalry.

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References


