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The Pattern of Supply Chain in Infant Industries: Some Case Studies on Energy Sector

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Abstract:
Firms of infant industries face certain challenges in forming effective supply chains. In this paper, we build on transaction cost economics to explore how supply chains can be formed in infant industries. We focus on two key aspects of supply chain formation: the make-or-buy decision and the strength of the ties between a focal firm and its suppliers. We utilize some-case study methodology, including seven start-up companies in the developing energy industry. We propose two models for supply chain formation in infant industries —'The Market Model' and 'The Maker Model'— and discuss the environments in which each model is appropriate.
Key Words: Supply chain, infant industries, energy sector.

Introduction:

Entrepreneurial ventures are common in infant industries, and although these bring new and innovative technologies to the market, they often lack the contacts and partners that firms in mature industries have established over years of operation. This leads the new ventures to engage in unstructured searches for potential supply chain partners. The objective of this paper is to explore supply chain formation models for firms in infant industries.

Infant industries are new industries in the early stages of development. Firms enter infant industries either as new firms or through diversification from other industries. Some infant industries arise primarily through the entry of new, independent firms, such as the many 'dotcom' firms in the mid-1990s or the many biotechnology start-ups in the 1980s (Hopkins, Crane, Nightingale, & Baden-Fuller, 2013). In the early phases of industry creation, new firms need to search and reach out across industry borders in order to gain necessary knowledge, complementary assets, partners, suppliers and potential customers to develop their businesses (Doz, Santos, & Williamson, 2001). Firms attempting to develop a supply chain and engage with potential suppliers, customers and other stakeholders face challenges due to infant industries' limited standards, limited numbers of renowned players, high market and technology risks and low external legitimacy due to limited track records (Aldrich & Fiol, 1994; Zimmerman & Zeitz, 2002).

The wave-and-tidal energy industry is one example of an infant industry. It is a pre-commercial industry comprising firms developing devices to harness energy from ocean waves and tides. Currently, the wave-and-tidal energy industry, and its special knowhow, is located in particular hot spots around the world, such as in countries around the North Sea.

I structure the paper as follows: In part 2, we review transaction cost arguments for the make-or-buy decision and for the strong versus weak ties in supply chain relationships. These perspectives are then applied to examine the features and context of the wave-and-tidal energy industry. In part 3, we present some-cases research methodology. In part 4, we present the details of the three specific cases. In part 5, we analyze the cases, present two models for supply chain formation in infant industries and discuss the conditions in which each model is suitable.

Review of Literature:

The literature on supply chain network formation has been primarily concerned with established firms in mature industries. Although much of the literature is applicable to entrepreneurial firms in infant industries, such industries also face a set of complicating factors and unique challenges that make supply chain formation particularly difficult. Transaction costs include the costs of searching for vendors, administering the transaction, risk hedging, control and follow-up. In addition to transaction costs, companies also face production costs, which are the actual costs of producing the product or service. The decision to make or buy is based on a comparison of the total costs of the two alternatives. According to Williamson (1975, 1985), there are three factors that particularly impact the transaction costs: transaction frequency, transaction uncertainty and asset specificity.

Transaction frequency refers to how often a transaction is repeated. The traditional argument is that if a transaction occurs often, internal transaction costs are lower than the transaction costs of an external relationship (Williamson, 1985). Hence, high transaction frequency suggests a hierarchical organization of economic activity.

Geyskens et al. (2006) find that higher levels of all three types of transaction uncertainty (i.e. 'behavioral', 'technological' and 'volume') tend to have the opposite effect and, furthermore, were all associated with arms-length buyer-supplier relationships. High uncertainty works against the development of tight relationships because actors hedge against the uncertainty by keeping alternative supply chain options open. Alliances can be seen as hybrids of hierarchical organizations and market organizations (Geyskens et al., 2006; Noote boom et al., 1997). The usual argument is that transaction costs can be significantly reduced by investing in trust and strong ties with suppliers (Dyer, 2002). In a buyer-supplier relationship, high transaction frequency and high asset specificity suggest that a tight relationship is the preferred choice precisely because transaction costs can be reduced. From a supply chain formation perspective, Lambert and Cooper (2000) suggest that the suppliers of critical importance to a firm's operations (e.g. due to high asset specificity and/or transaction frequency) should be managed more closely than others. Furthermore, Wu and Ragatz (2010) suggest that close relationships foster joint learning in product development processes.

In particular, technological uncertainty is high in the emerging wave-and-tidal energy industry for numerous reasons. First, since it has existed in a pre-commercial phase for almost two decades, the industry has limited credibility. Second, the lack of a dominant design has led to a wide variety of technologies, with few industry standards or standardized solutions. This, in turn, has made potential suppliers cautious to engage in the industry because the customer base of new solutions might be inadequate (Magagna et al., 2014). Third, the size, weight and complexity of the technologies in this industry leave few options in the market, as these technologies requires expensive and specialized production assets. Finding and attracting potential alliance partners is, consequently, a challenge.

In summary, all types of buyer-supplier relationships have some merit in the wave-and-tidal energy industry. The transaction cost perspective offers competing arguments in favor of all three generic formations (make, buy or ally). The 'best' solution depends on a case's particular situation. In this paper, we explore which configurations are the preferred choices under different conditions.

Objective of the Study:

1. To review transaction cost arguments for the make-or-buy decision.
2. To analyze the strong versus weak ties in supply chain relationships.

3. To analyze the models for supply chain formation in infant industries and find the suitable model.

Methodology:

I have done a multiple-case study to explore supply chain configuration issues in the emerging wave-and-tidal energy industry. Case studies are particularly helpful when exploring the details of real-life and infant phenomena. To observe supply chain configuration in the emerging wave-and-tidal industry, we searched for case firms that either had conducted or were close to conducting prototype tests in ocean environments as this is the technological milestone for this industry. The chosen cases were small firms located in Finland, Sweden and the UK.

Our primary data sources are seven semi-structured interviews conducted in the case companies in 2012 and 2013 as part of a more comprehensive study of the emerging wave-and-tidal energy industry. The interviews lasted 60 to 90 minutes and focused on the basic product concept, the company background, investor involvement and financial challenges, the technology development process, the supply chain configuration and partnerships. All interviewees were senior managers or founders still active in the firms and were thus knowledgeable about their firm's history, development and status. All interviews were transcribed and manually coded.

Characteristics of the case companies:

Case Firm-1
Firm name: Wello
Established: 2008
Country: Finland
Number of employees: 12
Technology: Wave
Product development status: Has since 2012 been testing a full-scale, grid-connected prototype in the Orkney Islands.
Full-scale unit: 0,5 MW 220 tones 30 meters

Case Firm-2
Firm name: Seabased
Established: 2001
Country: Sweden
Number of employees: 31
Technology: Wave

Product development status: Has manufactured the first 42 units (25 kW) of a 10 MW park, which is scheduled to begin operation in 2015.
Full-scale unit: 100 kW 12 tones 4 meters (buoy)

Case Firm-3
Firm name: Pelamis
Established: 1998
Country: UK
Number of employees: 55
Technology: Wave
Product development status: Has built and tested six full-scale units.
Full-scale unit: 750 kW 1350 tones 180 meters

Case Analysis:

Case 1: Wello

Wello's technology, the 'Penguin', converts the movements of waves to electricity. An asymmetric sea vessel is equipped with spinning rotators, which generate electricity as the vessel continuously adjusts to the waves. The full-scale device is 30 meters long and weighs 220 tons. Wello has focused on using existing, off-the-shelf components from the wind energy industry in the product design. This has given the company at least two to three choices for all of its device's components, allowing Wello to replace suppliers if necessary. The CEO explains as follows: 'We do not want to depend on any particular supplier, and always want to keep our options open'. Wello does not plan to build anything in-house. The manufacturing of the main structure and the assembly of parts can be done by most shipyards. Despite Wello's focus on using off-the-shelf components, some supplier-developed components require minor modifications. Engaging potential suppliers has been hard since several suppliers have been reluctant to do one-off deliveries due to Wello's small size, especially when their components need to be modified to fit Wello's device. For its prototype, Wello chose a smaller shipyard to handle building and assembly. This smaller shipyard was interested in a long-term relationship and was thus willing to discuss and help solve Wello's problems, while larger shipyards were too difficult to cooperate with since building the prototype was such a relatively small order. In short, Wello's model is based on arms-length relationships with suppliers and contract manufacturers.

Case 2: Seabased

Seabased has developed a wave energy technology that consists of a unit placed on the sea bed connected to a buoy on the surface via a line, which captures the energy in the motion of the waves and thus enables it to generate electricity. The company is a spin-off of the Swedish University of Uppsala. It has collaborated closely with the university on research and development ranging from theoretical concept studies to extensive, multi-year empirical testing in real ocean environments. This collaboration has given Seabased access to the university's personnel and facilities, allowing the company to develop core knowledge in both energy conversion and electrical transmission processes. The research at the university has helped finance the technology development and enabled Seabased to maintain a significant level of independence and protect its expertise.

Seabased has previously made 16 different prototypes, including both full-sized and smaller-scale prototypes. In 2014, the company opened a manufacturing facility in Sweden, where it has begun the manufacturing of devices for a pilot power plant consisting of around 400 devices. The strategically most important components used in the manufacturing process are commodities (e.g. magnets, cables and springs) which can easily be delivered by alternative suppliers. The company's long-term strategy is in-house mass production of devices, as exemplified by the following statement by the CEO: 'We feel that our set-up has a big advantage in series production'. In short, Seabased is a vertically integrated manufacturer with arms-length relationships with commodity suppliers.

Case 3: Pelamis

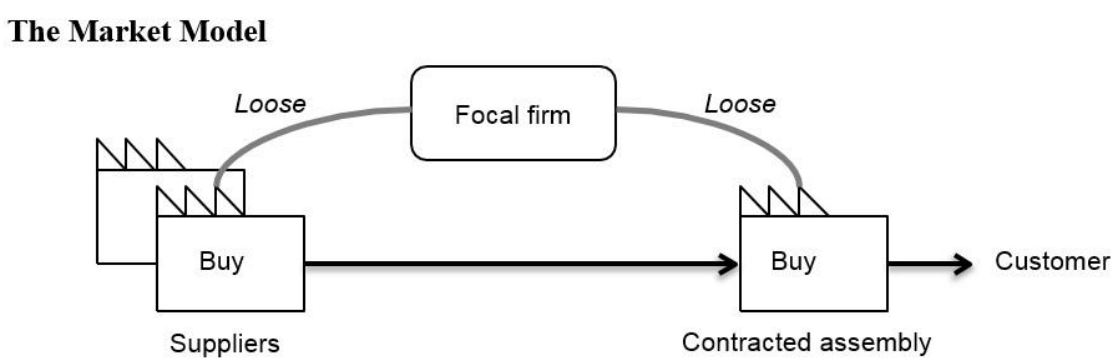
Before Pelamis went bankrupt in 2015, its wave energy device was an attenuating line absorber. It was a huge floating tube divided into five sections and measuring 180 meters long and 4 meters wide. It generated power by the waves' movements, which force the device to rise and fall in snake-like motions. Pelamis was one of the first companies conducting successful tests of their wave technology in the early 2000s. This gave Pelamis a lot of publicity and it acquired a significant amount of private capital in an earlier phase of the industry. This funding made the company an industry leader, which again attracted more capital and made it possible for Pelamis to build its own production facilities in Edinburgh, Scotland, where the company produced six prototypes of its device. The device required special facilities for assembly and deployment, and after having built their first unit it was clear that internal manufacturing was a desirable solution. The senior manager explained as follows: 'Instead of contracting someone for the design and somebody else for the assembly, we realised that it is through in-house manufacturing we really learn about the product'. Pelamis experienced challenges engaging the right suppliers. In the beginning, engaging large manufacturers was extremely difficult because Pelamis' device was so radical and the wave industry was almost non-existent. Furthermore, attracting larger suppliers to produce one-off components proved problematic. Instead, Pelamis engaged smaller suppliers, which are more flexible but are still not ideal, since they have limited financial and human resources. Pelamis' production of its first three prototypes led to extensive publicity, which (along with the fact that the product was now 'proven') attracted large suppliers that had dismissed Pelamis earlier. As a result, Pelamis switched out some of its smaller suppliers for larger ones.

Although several of its suppliers offer modifications of their original components, Pelamis avoided exclusivity deals, instead focusing on having alternative suppliers for all of the components. In short, Pelamis preferred arms-length relationships with small and large suppliers that delivered to the company's own manufacturing facility.

The Market Model

The firms that utilise the Market Model outsource component production to suppliers and the manufacturing and assembly of the final device to contract manufacturers (e.g. yards). The firms do not regard any of their suppliers as key suppliers since they focus on using off-the-shelf components (i.e. components that already exist in the marketplace). They maintain weak ties to their suppliers because they want the flexibility to replace any supplier within a short timeframe, if necessary. Furthermore, because the focal firms do not consider any of the single components to be key technologies, their strategy is to deliver the design and integration of the total solution.

As long as components are commodities or need only minor modifications, the asset specificity is relatively low, and an arms-length buyer-supplier relationship is preferred. This gives the focal firms the advantage of being able to choose from among a wide variety of suppliers (Williamson, 1985), which helps to keep costs down and the time to market short.



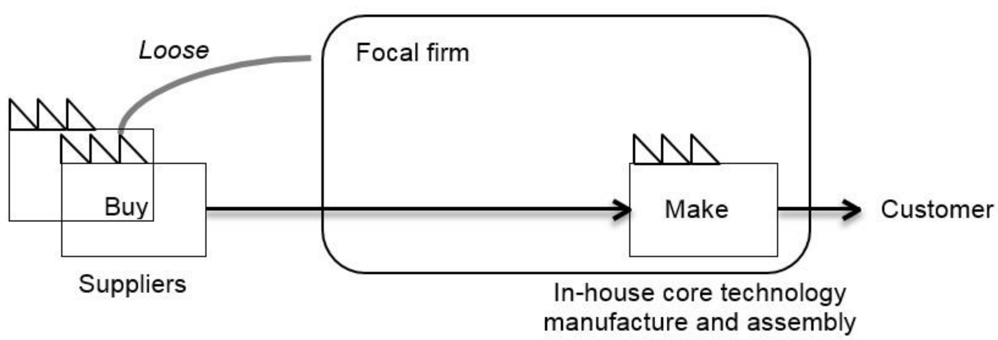
Another advantage of buying off-the-shelf components from the marketplace is that this approach also lowers technological uncertainty, which reduces transaction costs. The arms-length buyer-supplier relationship gives focal firms the flexibility to terminate non-functioning relationships and switch to other suppliers (Balakrishnan & Wernerfelt, 1986;

Geyskens et al., 2006). Furthermore, the strategy of buying existing components makes it easier to identify and engage suppliers than if their components required major modifications. Finally, a generally high transaction uncertainty results in a preference for arms-length buyer-supplier relationships, which makes it possible to quickly reconfigure the supply chain (Geyskens et al., 2006).

The Maker Model

The firms that use the Maker Model manufacture and assemble their devices in their own manufacturing facilities. They have arms-length relationships with their suppliers, which deliver commodities or components with only minor modifications. Key components are kept under internal control and are manufactured by the focal firms in-house.

The Maker Model



When final devices are characterised by high asset specificity, transaction cost economics advises to organise the manufacturing hierarchically to minimise transaction costs. Furthermore, the high transaction uncertainty in emerging industries favours a hierarchical organisation, which gives focal firms greater control over internal relations (Williamson, 1975). Another clear advantage of a hierarchical organisation is that it gives firms full control over the development and manufacturing of core technology. Furthermore, as suppliers in this model only deliver commodities or components with minor modifications, focal firms can maintain arms-length buyer-supplier relationships. This configuration gives them a wide choice of suppliers in the short to medium term, thereby helping to reduce transaction costs (Williamson, 1985).

On the other hand, a clear disadvantage of this model is the significant financial investment needed to build manufacturing facilities and expand the organisation. In addition, the size, weight and complexity of the products require expensive and specialised production assets. This could represent a major obstacle for small firms, especially within capital-intensive industries like the wave-and-tidal energy industry in which funding is hard to obtain (Leete et al., 2013). As our case descriptions illustrate, the case companies have followed different paths that led to choosing the Maker Model. The position as a frontrunner in the industry helped Pelamis attract a considerable amount of private capital. Seabased's tight connection with the university directly benefited its technology development (and lowered its financing requirements), while Flumill accessed production facilities through one of its owners. This made it possible for these three firms to overcome the financial challenge and invest in developing their own technology and assembly or manufacturing facility. As in the Market Model, maintaining arms-length relationships with suppliers gives the focal firms utilising the Maker Model limited legitimacy via suppliers.

Conclusion

This paper has focused on an understudied area in both the supply chain literature and the literature on emerging industries: the configuration of supply chains in emerging industries. Overall, the study confirms that it is very challenging to strategically configure supply chains in the early stages of emerging industries. In these industries, there are often no established supply chains in the first place. Therefore, firms often engage in unstructured searches for suppliers and partners. Our purpose was to explore how these firms can configure more suitable supply chains. Through a multiple-case study of seven companies in the wave-and-tidal energy industry, we identified three general models of supply chain configurations in emerging industries. We focused on the decision to either make or buy components and manufacturing capacity, as well as on firms' levels of integration with suppliers.

The three proposed supply chain models for emerging industries are as follows: (1) the Market Model, (2) the Maker Model. In short, the decision to manufacture or assemble the final device (i.e. the Maker Model) gives the focal firm control over key competences or technologies. However, though classical arguments in transaction cost theory prefer this model, it is particularly difficult to realise in emerging industries due to resource requirements. A particular challenge is the need to attract the necessary investment capital. Finally, the Market Model, based on arms-length relationships with suppliers, keeps alternatives open but lacks the benefits of cooperative technology development and legitimacy-building partnerships.

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