The role of manufacturing innovations in production relocation decisions

Manufacturing innovations are technologies and activities that improve and change the level of capacity, performance and quality in manufacturing permanently or over time. This policy brief explores the role of manufacturing innovations in different Nordic contexts, their link with production relocation decisions and performance implications. Manufacturing innovations are analyzed in terms of four dimensions: manufacturing technology innovations, process innovations, delivery chain innovations, and disruptive innovations. The manufacturing firms’ relocation decisions are also analyzed, from the perspective of perceived importance of relocation. Performance is assessed in terms of cost efficiency improvement and performance within industry in terms of quality, delivery lead time and flexibility (QDF).

A questionnaire survey was conducted among manufacturing firms in Finland, Sweden and Denmark, and altogether 847 persons responded, each representing a different manufacturing firm. The survey explored the extent of offshoring and backshoring of production among the Nordic manufacturing companies. Offshoring and backshoring refer to relocation of production permanently from one geographic location to another location, either from the home country to another country (offshoring) or bringing it back to the home country (backshoring). In both offshoring and backshoring, the ownership of the relocated production may or may not change. Additional qualitative data were collected through interviews with managers involved with implementing radical manufacturing technology innovations in Finland.

The results show cross-country differences in manufacturing innovation patterns, relocation importance and performance. Respondents in Swedish and Danish firms have assessed their manufacturing innovation patterns, relocation importance and performance higher than respondents in Finnish firms. Companies that have done backshoring of production (backshorers) appear as more active in manufacturing technology innovations, and there is no difference compared other companies in delivery chain innovations, disruptive innovations and process innovations. Backshorers have a higher score in QDF performance than the other companies, whereas companies with different relocation patterns do not differ in their cost efficiency.

The findings raise three main questions for policy development in the renewal of manufacturing in Finland:

- What explains the country differences in manufacturing innovation activity and relocation patterns between Finland, Denmark and Sweden?
- How can purposeful backshoring and related manufacturing innovations be promoted?
- How can the success factors of radical manufacturing technology innovations be enhanced in different types of industrial firms, in uncertain conditions?
This policy brief focuses on manufacturing innovations: ways in which the capacity, performance and quality of manufacturing can be changed through investments.

**Introduction**

Innovation research has largely focused on how customer needs drive new products and how product innovations drive improvements and innovations in manufacturing. Previous research on radical manufacturing technology innovations (RMTI) has focused on the adoption and integration of novel technology-based equipment (e.g. Khazanchi et al. 2007; Dewar and Dutton 1986; Gomez and Vargas 2012; Sinha and Noble, 2008). The attention has been limited to the selection and adoption of technologies developed elsewhere, mainly by specialized equipment suppliers. The processes of generating and adopting innovations are distinct phenomena that are facilitated in different organizational conditions, often technology suppliers generating the innovations and manufacturing firms adopting them (Damanpour and Wischnevsky 2006).

Advanced manufacturing technologies have been the main domain of research concerning manufacturing technology innovations (Khazanchi et al. 2007). Typical examples of advanced manufacturing technologies include computer numerical controlled machines, computer aided design, robotics and flexible manufacturing systems, and these technologies share a typical characteristic that they are easy to integrate electronically (Gomez and Vargas 2012). Some research focuses more on advanced production control through such means as manufacturing planning systems, i.e., Just-in-time, Manufacturing Resource Planning and Enterprise Resource Planning (Swink and Nair 2007). Besides manufacturing technology innovations, a lot of attention goes to changes in processes and delivery chains connected with manufacturing. Delivery chain and process innovations may or may not involve the use of new technology, and accordingly can be divided into technological and organizational types (Reichstein and Salter 2006). Adoption of RMTI is a major source of radical supply chain process innovations in manufacturing firms (e.g. Reichstein and Salter 2006; Hervas-Oliver et al. 2014). Some of the manufacturing innovations may be incremental, but there is increasing interest towards disruptive innovations (Christensen 1997). Technologies can be considered disruptive if they “change the bases of competition by changing the performance metrics along which firms compete” (Danneels 2004). Such novel technologies can open up new markets and eventually seize also old markets earlier dominated by other kinds of technologies (Druehl & Schmidt 2008).

This policy brief explores whether and how manufacturing innovations differ across different contexts, and whether manufacturing innovations differentiate firms’ location decisions and performance.

**Materials**

We use questionnaire data from Finnish, Swedish and Danish manufacturing firms, and interview data in selected Finnish firms. A questionnaire survey was carried out in the autumn of 2015, investigating the extent and drivers of manufacturing companies’ production offshoring and backshoring in Finland, Sweden and Denmark. The targeted companies consist of all the manufacturing companies with a minimum of 50 employees in all the manufacturing industry categories (SIC code 10-33). With a population of 4590 targeted companies, the overall response rate was 18.5%. The number of manufacturing companies participating in the survey was 229 in Finland, 373 in Sweden and 245 in Denmark. Tampere University of Technology was responsible for executing the survey in
The primary data are questionnaire responses from 847 manufacturing firms in Finland, Sweden and Denmark. Additional interview data are from 23 radical manufacturing technology innovations.

Manufacturing firms are active in process innovations. Finland, whereas Lund University was responsible for Sweden and University of Southern Denmark for Denmark. The questionnaire was developed jointly.

A majority of the respondents are from firms in machinery industry and equipment (18,8%), fabricated metal products (11,2%) and food industry (10,5%), other industries having fewer than 7% of the sample each. Different sizes of firms are well covered (22,3% with 51-100 persons, 28,9% with 101-250 persons, 11,6% with 251-500 persons, 36,2% with over 500 persons). There are some differences across the three countries in terms of the company size; the Finnish sample has relatively higher proportion of small firms, whereas Sweden has a relatively higher proportion of large firms. There are also differences in the industries represented according to the industry structures in the three countries.

The questionnaire covered three levels of manufacturing related issues: the company, the recent offshoring and/or backshoring decisions, and the focal plant. This policy brief focuses on issues concerning manufacturing innovations in the company and the focal plant, and linked relocation issues, and performance. Multi-item scales were developed, so that each measure of manufacturing innovations, importance of location changes, and performance included multiple items, with a five-point Likert scale for responses. The content of the variables is available upon request from the authors. The validity of the measures was tested through a factor analysis, and reliability for the measures was established through reliability coefficient Cronbach’s Alpha. In this policy brief we report comparisons between countries, between groups displaying different location decisions, and between performance clusters, using one-way analysis of variance.

To complement the questionnaire data qualitatively, we conducted interviews on radical manufacturing technology innovations in 23 manufacturing firms in Finland. Production development managers/directors of selected technology-intensive firms were contacted to enquire their examples of radical production technology shifts. The interviews focused on, e.g., the drivers and process for the RMTI, and challenges and success factors in its realization. We will here report the experienced barriers and success factors of RMTI.

**Results**

**Manufacturing firms’ relocation activities and differences in manufacturing innovations, location choices and performance**

According to the questionnaire respondents, the firms pursue Process innovations (i.e. reorganization of resources, changes in routines, business process improvements, changes in earning logics) on average to a fairly high extent (mean 3,54, standard deviation 0,69), and Delivery chain innovations (i.e. new kinds of services, new customer relationships, new supplier relationships, cooperation with competitors) to a moderate extent (mean 3,02, s.d. 0,66). The extent of Manufacturing technology innovations (i.e. new process technologies, digitalization, new high-tech materials, automation and robotization) is also moderate (mean 2,81, s.d. 0,90), whereas the extent of Disruptive innovations (i.e. making obsolete some customer relationships, supply/delivery chains, value propositions, supplier partnerships or processes) is fairly low (mean 2,46, s.d. 0,90), which was as expected.

Figure 1 summarizes the differences between countries. The country-specific responses do not differ from each other at a statistically significant level in Process and Delivery chain
Firms in different countries differ from each other both in disruptive and technology innovations, and performance.

Finnish manufacturing firms assess both innovation and performance measures lower than firms in Sweden and Denmark.

Innovations. The cross country analysis reveals which countries differ from each other and shows that respondents of manufacturing firms in Denmark have assessed the extent of Manufacturing technology innovations higher than Sweden and Finland (p<0,05). The respondents in Sweden have assessed the degree of Disruptive innovations higher than in Denmark and Finland, and Denmark also higher than Finland (p<0,001).

![Figure 1. Cross-country comparison of manufacturing innovations, relocation importance and performance. (stars denote the statistical significance of differences: black p<0,001; grey p<0,01, white p<0,05)](image)

Relocation importance deals with the role of production location choices in the company’s strategy (location changes receiving attention, their influence on the direction of business, and seeing offshoring and backshoring as strategic alternatives for the manufacturing footprint). The respondents consider that relocation issues have a moderate to somewhat high importance in the company’s strategy (mean 3,27, s.d. 0,94). There is a significant difference between the countries: respondents in Denmark have rated the strategic importance of location changes higher in the company strategy than Finland and Sweden (p<0,05).

We also inquired aspects of performance of the respondent’s manufacturing plant in terms of Cost efficiency (reduction of total costs and unit costs, and improved productivity and product profitability) and QDF performance within the industry (being among industry leaders in product quality, delivery lead times and flexibility) of the company. On average, the respondents rated both dimensions as rather high: Cost efficiency (mean 3,85, s.d. 0,75) and QDF performance (mean 4,13, s.d. 0,67). There are significant differences between countries: the respondents in Denmark rate both Cost efficiency (p<0,001) and QDF performance (p<0,05) higher than Finland and Sweden; and also Sweden’s scores are higher than Finland in Cost efficiency.

Relocation decisions and manufacturing innovations

In order to understand what role manufacturing innovations play with regards to relocation decisions, we analyzed the differences between companies that have made quite different
Backshorers are more active than the other firms in manufacturing technology innovations.

Non-movers innovate less and perform weaker than movers.

relocation decisions, in terms of offshoring or backshoring. The majority of firms (n=461) had not made such movements (non-movers), whereas 193 firms had done only offshoring (offshorers), 81 firms had done only backshoring (backshorers), and 77 firms had done both offshoring and backshoring (multi-movers). Figure 2 reports the comparison.

Figure 2. Comparison of manufacturing innovations, relocation importance and performance across companies with different relocation profiles.

Companies with different location decisions do not differ from each other in Delivery chain innovations, and the cross-group differences in Disruptive innovations and Process innovations, as well as Cost efficiency, are minor (i.e. the pairwise differences are not significant even if the overall difference is). Instead, three statistical differences are interesting. Those companies that have done only backshoring, are also more active than the other firms in Manufacturing technology innovations (p<0.01). The strategic importance of location changes differs across firms clearly (p<0.001) and in a very logical way: those doing offshoring or both offshoring and backshoring assess the strategic importance of location changes higher than those doing only backshoring, or not moving manufacturing. The QDF performance measure differs across groups (p<0.05) - the firms with only backshoring have a higher QDF performance score than in the other groups. Backshoring, thereby, appears to be linked with Manufacturing technology innovations as well as QDF performance.

Manufacturing innovations and performance

To analyze how firms with different types of performance profiles differ in their manufacturing innovations, we clustered the firms based on Cost efficiency and QDF performance. Firms with an average performance below 4 were categorized into “low”, and 4 or above were categorized “high”. The majority of firms fell into the category of high Cost efficiency and high QDF performance (n=336); 238 firms had high QDF performance and low Cost efficiency, 102 firms had high Cost efficiency and low QDF performance, and 126 firms were categorized with low Cost efficiency and low QDF performance. These four clusters of respondents were then compared with each other, in terms of their manufacturing innovations.
Active innovators perform better particularly in cost efficiency.

Manufacturing firms perceive various barriers and have experiences of important success factors in radical manufacturing technology innovations.

The analysis shows a tendency where the firms with high degrees of Cost efficiency also report higher rates in all types of innovations and strategic importance of location changes. This difference is particularly clear in Manufacturing technology innovations (p<0.001), Disruptive innovations (p<0.001) and Process innovations (p<0.001). In Delivery chain innovations (p<0.01), the companies with both high Cost efficiency and QDF performance have a higher innovation level than the other performance clusters. These findings suggest that the active pursuit of manufacturing innovations is either justified by or reflected in higher Cost efficiency in performance.

Barriers and success factors in radical manufacturing technology innovations

The interviews on the 23 different radical manufacturing technology innovations in Finnish firms revealed a variety of barriers and challenges to innovations, as well as success factors. Many of the barriers stem from the perceived novelty, technical uncertainty and market uncertainty associated with the innovation and may terminate or slow down the innovation process, unless proper capabilities, partner networks and strategic justifications are available. Table 1 summarizes the key challenges and success factors identified.

Table 1. Summary of challenges and success factors in radical manufacturing technology innovations.

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<tr>
<th>Characteristics of RMTI</th>
<th>Main challenges</th>
<th>Main success factors</th>
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<tr>
<td>Novelty</td>
<td>Lack of experience</td>
<td>Technical experts</td>
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<td></td>
<td>Lack of credibility</td>
<td>Learning period (trials, training, dedicated resources for learning)</td>
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<td>Lack of enough interested partners</td>
<td>Strategic need/ fit</td>
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<td>Interested individual(s)</td>
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<td></td>
<td>Promotion of the idea</td>
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<td>Technical uncertainty</td>
<td>Unexpected errors</td>
<td>Technical experts</td>
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<td></td>
<td>Delays</td>
<td>Prototypes</td>
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<td></td>
<td>Creating a shared vision/ideas among stakeholders</td>
<td>Strategic need/ fit</td>
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<td>Supplier’s competence</td>
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<td>Resources for problem solving</td>
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<td>Communication</td>
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<td>Market uncertainty</td>
<td>Customer acceptance</td>
<td>Strategic need/ fit</td>
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<td></td>
<td>Unknown profit</td>
<td>Strong personality, “champion”</td>
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<td></td>
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<td>Customer involvement</td>
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Implications to innovation policies and action

Both manufacturing innovations and relocating a firm’s manufacturing operations in a different country are significant investments that feature novelty and uncertainty to the firm. They both also influence other stakeholders than the manufacturing firm: customers, the supply and delivery network, technology suppliers, potential financiers, partners, consultants, research institutes, and many more. The ecosystem effects with manufacturing related investments are significant.

This study has shown that Finnish manufacturing firms’ recent experience with manufacturing innovations is not particularly substantial. This is likely to cause barriers
What explains the country differences in manufacturing innovation activity and relocation patterns between Finland, Denmark and Sweden?  

How can purposeful backshoring and related manufacturing innovations be promoted?  

How can the success factors of radical manufacturing technology innovations be enhanced in different types of industrial firms, in uncertain conditions?  

(stemming from novelty and uncertainty) to initiating, creating and implementing manufacturing innovations. We also showed that Swedish and Danish firms showed more activeness toward innovations and appeared to experience business benefits particularly in terms of cost efficiency. We need to find out why. Differences in country policies, support mechanisms and practices may be relevant.

Our study treated manufacturing innovations as a multi-dimensional concept, thereby drawing attention to the many ways in which manufacturing can be renewed. The investment into innovation may well be connected with relocation choices. The results showed that active backshorer firms tend to be more active in manufacturing technology innovations and process innovations and perform better in cost efficiency than other firms. We need to research and develop processes and procedures that promote success in manufacturing investments broadly – be it innovation or relocation.

The results revealed barriers and success factors for radical manufacturing technology innovations. Particularly the novelty, lack of previous experience and knowledge, and risk avoidance indicate a strong need for cross-company learning and cooperation. Policy making should take into account how the barriers can be removed and success factors be enhanced in manufacturing firms of any types and sizes.

Further readings


