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A Production Transfer Risk Assessment Framework

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Abstract. Many companies transfer production between them as part of relocation processes such as offshoring and outsourcing. Such production transfers (PT) are often associated with the risk of not achieving the expected performance results. Thus, many scholars and practitioners have acknowledged the importance of a thorough PT planning, based on risk management principles. One major principle is the assessment of PT risk in early stages of the process, in order to identify risk factors, analyze potential risk scenarios generated by the factors, implement risk-mitigation actions and improve PT performance. While several scholars have recommended conducting assessments early in the transfer process, which through the risk management lens, can be regarded as variants of risk assessment, there has not been published any recent review of the extant research on the risk assessment early in the PT process. Thereby, the main objectives of this paper are to identify and classify potential risk factors in the extant research, propose an assessment tool and test its utility on a longitudinal PT case. The paper also provides suggestions of how to apply the proposed tool to evaluate the requirements for resource intensive activities between the PT parties.

Keywords: Production Relocation, Supply Chain Risk Management, Performance Management, Offshoring, Outsourcing

1 Introduction

Many companies carry out production transfers (PTs) as part of relocation processes such as offshoring or outsourcing [1]. In line with [2], a PT can be defined as the relocation of the manufacturing of products and components between a *sender* (original manufacturer) and a *receiver*. Further, it can be divided into three main phases: (i) '*PT preparation*', (ii) the '*PT execution*' mainly consisting of the physical transfer of production equipment and inventories, and (iii) the production '*start-up*' at receiver. A PT is usually considered successful if a stable production is achieved at the expected performance objectives (e.g., cost and yield), in the start-up [3,4]. The PT can be regarded as the final stage in a production relocation process, being usually preceded by the decision whether to relocate production or not, and the selection of suitable sourcing items, locations and suppliers [5]. All the new risk factors introduced when transferring the production to a new production environment (e.g. a new workforce, production

equipment and sub-suppliers) contribute to an increased risk level. For PTs, the ‘*risk factors*’ can be defined as tangible and intangible elements which have the intrinsic potential to give rise to supply-disruptions[6]. Although they are a common phenomenon, PTs tend to take much longer time than companies anticipate [7]. Further, they do not always meet the expected performance objectives, and can even lead to losses (e.g. financial or intellectual property (IP) losses)[8]. Thus, many scholars and practitioners have acknowledged the importance of thorough PT planning and control, based on risk management principles (e.g. [9,3]). Two central risk management goals are the risk assessment and the risk mitigation process. For PTs, the assessment consists of the following activities: the identification of risk factors, potential supply-disruptions (e.g. a machine breakdown) generated by these factors and their effect on performance; an analysis to understand risk scenarios and estimate the level of risk, and an evaluation of whether risk-mitigation actions should be implemented or not [10]. Several scholars [e.g. 9,11,12] have recommended conducting assessments in the early stages of the PT process that, through the risk management lens, can be regarded as variants of risk assessment. Such assessments indicate potential sources of disruptions in the material and information flow (i.e. risk factors), and can aid in identifying risk-mitigation actions that should be included in the PT action plan. Nevertheless, to the authors’ knowledge, there has not been published any recent review of the extant research on the risk assessment early in the PT process. Thus, the research problem this paper addresses is ‘*What are the risk factors during PTs?*’ and the main objectives are to identify and classify potential PT risk factors in the extant research, and, thereby, propose a risk assessment tool. Moreover, the utility of the proposed tool is tested on a PT case.

Research Methodology

The research process has been conducted in two steps. First, we have carried out a literature review of peer-reviewed journal articles, dissertations, and best practices within the topics of *production-*, *knowledge-*, and *technology-transfer*, as well as about *manufacturing relocations and start-up*, *supplier assessment and audit*, and *key risk management* publications. The aim of the review was to identify potential PT risk factors. When synthesizing these factors into the proposed assessment tool, the most comprehensive frameworks found [9,11,12] were taken as a starting point. Second, a case study is used to test the utility of the tool. The case is the PT of electronics from a Norwegian company to a subsidiary in Spain. Rich empirical data has been collected during a period of 12 months. The case method was adopted because it allows the identification of PT risk factors during a real PT case and with a relatively full understanding of the nature and complexity of the PT process[13]. The sender had conducted PTs several times before, including to the receiver. Yet, they were experiencing a series of challenges during PTs. This made the selected PT an interesting case to study and get a better understanding of how to identify areas where risk-mitigation actions could be implemented in order to improve supply performance. Further, the PT project owner and the sender’s PT Quality & Risk manager applied the tool to the case, 6 months after the PT decision. Both had rich experience from similar PTs. A semi-structured interview was conducted with the informants, who jointly analyzed and ranked the impact

of the risk factors on the overall risk level during the case. Responses were cross-referenced with documentation and extensive field notes.

2 Potential Risk Factors during Production Transfers

Supplier qualification assessments are widespread in the scientific literature. Grant and Gregory [11], pioneers of the PT literature, argue that the PT success would not be only influenced by factors dependent on receiver but also by those inherent in the type of production transferred, and best controlled by sender. Thereby, based on [11], we have established the two first categories of literature findings: *'potential risk factors related to the transfer object'* and *'to the receiver'* respectively (see framework in Table1). These factors have been further divided into five and nine areas respectively. The Risk factors related to the receiver can be encountered in the widespread supplier qualification assessments. Although these factors do not necessarily affect the selection of the receiver, they might still contribute to an increase in the PT risk level, and should therefore not be overseen. Moreover, WHO [9] recommends visiting the receiver early in the transfer process, in order to assess the new production environment at a more detailed level, and shed light on the capability gaps between the receiver and the sender. Thus, the 'production environment' area was added, and several factors in this area can be also encountered in Lean audits (i.e. R35, R36, R37 in Table 1).

Next, according to [3,12] the PT outcome will be also influenced by the physical distance and the relationships within the supply chain. Thus, a third category was added to our classification, *'factors related to supplier relations'*. Finally, based on the widely used Kraljic model[14], the *'factors related to the profit impact'* a sourcing activity has, should be always considered along with the risk factors. According to [14], these factors stand out and have a moderating impact on the risk level. If the risk level is high, it is worth making high investments in the sourcing, provided the profit impact is also high. The 4 categories of risk factors are presented in Table 1. The factors have been divided into 18 distinctive areas. [9,11,12] were taken as a starting point for the framework.

Table 1. Framework for production transfer risk assessment

I. Risk factors related to the transfer object	
<p>1. Novelty</p> <p>R1. Degree of experience sender and receiver have with transferring production between them [15,16]</p> <p>R2. Sender's and receiver's individual experience with similar production [15,16]</p> <p>R3. The similarity of the transfer object produced by receiver to the object produced by sender [15]</p> <p>R4. The similarity of the transfer object produced by receiver to other production at receiver (e.g. if receiver's equipment can be used) [16]</p> <p>R5. Production site's maturity (e.g. greenfield or brownfield) [17]</p> <p>2. Complexity</p> <p>R6. Degree of internal and external modularity (e.g. the object is part of a larger system) [15,18]</p> <p>R7. Amount of elements, configurations and functions the object has (e.g. BOM complexity) [15,18]</p>	<p>R8. The size of the product tolerances [16]</p> <p>R9. Availability of raw materials [14]</p> <p>R10. The extent to which the manufacture of products is complete prior to customer order [16]</p> <p>R11. Customer demand- and volume-certainty [16]</p> <p>R12. Facility to protect IP [11]</p> <p>3. Tacitness</p> <p>R13. The facility to codify (document) the tacit knowledge about the object [15,11]</p> <p>R14. The transfer object's maturity (e.g. with well-defined processes) [15,11]</p> <p>R15. The relevance of the documentation (e.g. updated and representative) [15,11]</p> <p>4. Adaptability</p> <p>R16. Facility to find alternatives when adapting the production process to receiver's environment [11]</p> <p>R17. Facility to pilot and test the adaptations at</p>

sender prior to transfer execution phase [11] R18. Sender's capability and willingness to make adaptations [11] 5. Flexibility R19. The possibility to reserve resources at sender	for necessary tasks during transfer execution and start-up at receiver [16,19] R20. The possibility to plan the transfer as a gradual transfer, volumes being only gradually decreased as outputs at receiver are increased [16,19]
II. Risk factors related to the receiver	
6. Sub-suppliers R21. The quality, cost, flexibility, service level, reliability and proximity of local and international sub-suppliers [11,8] 7. Transfer market R22. The appropriateness of receiver's market for the transferred production (e.g. if product redesign is needed to satisfy demand) [11] 8. Infrastructure R23. The appropriateness of the quality, cost and availability of local utilities [11] R24. The appropriateness of the space and format of buildings [11] R25. The appropriateness of tele-communications, road, rail, shipping and airfreight infrastructure [11,8] 9. Legal requirements R26. The appropriateness of import duties [11,8] R27. The appropriateness of quotas, labor law, government emission regulations, planning permission regulations, approval and license requirements, and other legal demands [11] 10. Financing R28. The appropriateness of the cost of capital, land, inventory, and the foreign exchange requirement [11] 11. Geographical environment R29. The appropriateness of the local temperature range, humidity level, air quality [11] and of georisk (e.g. if area is prone to natural disasters) [14] 12. Sociopolitical environment	R30. The level of governmental stability [14] 13. Labor force R31. Employee's productivity, educational level, language homogeneity and turnover [11] 14. Culture R32. The closeness between job positions (e.g. manager-operator) R33. Individuals' willingness to assume responsibility and the appropriateness of receiver's approach to problem solving and quality perception [11] 15. Production environment R34. Production and packaging rooms, the testing, production and packaging equipment, inventory control mechanisms, documentation, the absence of banned substances, waste management [9] and other HSE aspects [20] R35. Layout and material flow; efficiency of space usage; levels of inventory and work-in-progress; quick changeover; installation and maintenance protocols; planning and control, value chain information sharing and other data systems (e.g. level of integration between systems); order management; quality management (e.g. TQM); Visual management [20,9] R36. Workers' technical capabilities (e.g., to adapt the production process to own environment and the use of leading technology); organizational practices (e.g., customer focus, housekeeping) [11,20] R37. Level of teamwork and worker empowerment and flexibility [20]
III. Risk factors related to supplier relations	
16. Distance R38. Physical proximity between related processes (e.g. the development and manufacturing units) after transfer execution [16,3] R39. The relationship closeness between sender and receiver [16,3] R40. The relationship closeness within the value chain (e.g. receiver has close sub-suppliers that deliver high quality items) [20]	R41. The similarity of transfer parties' perception of their relation [21] 17. Power balance R42. Sender's and receiver's negotiating power [14] 18. Motivation R43. Employees' motivation for transfer, at both locations (e.g. high when no lay-offs) [16]
IV. Risk factors related to profit impact	
R44. The size of the sourced volume compared to sender's and receiver's other products [14,16] R45. The proportion of sender's total sourcing	cost the sourced items stand for [14] R45. The positive impact of the sourced items on quality and business growth [14]

3 Case Description and Analysis

The case we have studied is a PT of one acoustic sensor product family from the domestic production site of a major Norwegian corporate group (*Sender*) to a financially autonomous subsidiary in Spain (*Receiver*). The production was offshored in order to get better access to the developed customer market and to the material technology expertise at Receiver, as well as to reduce labor cost and delivery time. Sender was transferring all the production activities to Receiver, apart from the acoustic technology, which contained a high IP level. Thus, Receiver was required to assemble the acoustic technology into housings from vendors, and mold, assemble, test and deliver final products. The PT decision was taken in spring 16', the Preparations started in September and the Start-up is estimated to start in June 17'. Further empirical findings are presented in Table 1. As explained in Section 2, the Project owner and Sender's Quality & risk manager for the PT analyzed and ranked the risk factors according to their contribution to increased PT risk level; the assessment was conducted 6 months after the PT decision. In the table, we have only displayed an average of all the factors' rankings in each area. Risk-mitigation actions could be implemented for the risk factors (or areas) in descending priority i.e., first for factors with 3- high contribution to increased risk, etc.

Table 2. Risk factors in the case (1-low/ 2-medium/ 3-high contribution to increased risk)

Related to the Transfer Object	<p>Novelty: Sender had transferred production several times before, but Receiver had initially only carried out sale and service operations for Sender and did not have much production experience. However, they had successfully undertaken production from Sender before (the assembly of a simple component), and they had been having a good collaboration for 20 years. Moreover, Receiver had employed a researcher with a PhD in material technology who was developing a new molding material, a process that could delay the transfer. Most of the machines had to be purchased and there were certain distinctions between this equipment and the original one at Sender. In addition, Receiver had bought these expensive machines too early (more than one year before start-up). Finally, because of increasing production activities, Receiver also had to buy a facility to move to before start-up, and its layout had to be changed. The constructors they contracted for the 1st part of the building project submitted a too costly offer for 2nd part, and the process of contracting new ones delayed the start-up with weeks.</p>	3
	<p>Complexity: The transferred object consisted of three product groups; each with three relatively simple products that were not part of Sender's other products. However, their production required many machines and tools that had to be either purchased or transferred from Sender. The demand was relatively certain; there was a good market for these products in Spain. Further, since it was rather difficult to protect the IP, Sender did not grant Receiver access to the document handling system, and little documentation had been transferred before Sender's representatives visited Receiver and saw that the material development process was promising. Because of the scarce information and Receiver's rush to start the production, the new layout at the purchased facility deviated from what the production required, and had to be modified after Sender's visit. Moreover, during one analysis conducted short time after kick-off, Sender's employees identified a certain risk of IP loss during the transport of the acoustic technology to Receiver, but actions were soon implemented to ensure that only qualified logistics suppliers are used.</p>	3
	<p>Tacitness: The transferred products were mature, but the documentation was not completely updated and a certain amount of tacit knowledge could not be codified. Thus, Receiver's operators had to travel several times than expected to Sender for hands-on and face-to-face training provided by Sender's operator and engineers. This could increase the transfer time.</p>	2
	<p>Adaptability: The production could not be changed and adapted to Receiver's environment.</p>	3

	Flexibility: Receiver was seeking a rather high transfer pace, because of the unutilized expensive equipment they had bought. Nonetheless, during the preparations phase, it became increasingly clear that a gradual transfer was necessary. To cope with the uncertainty, Sender decided to continue producing for a couple of months, until Receiver achieved a stable production. Moreover, since one of the reasons for the transfer was to release resources for innovation (Sender's core competency), the amount of resources Sender was willing to invest in the transfer was moderate. Yet, Sender assigned significant resources to travel to Spain and assist Receiver during transfer execution and start-up.	1
Related to the Receiver	Sub-suppliers: The sub-suppliers' performance is evaluated as moderate. In addition, during one workshop, Receiver's personnel identifies a certain risk that sub-suppliers could unexpectedly stop their supply and thereby, it is decided to establish a long-term partnership with critical vendors and have available secondary sub-suppliers for standard items.	2
	Transfer market: The transfer parties benefited of a good and stable customer demand in Spain, without having to change the products.	1
	Infrastructure: The infrastructure at the Spanish receiver is evaluated as very good.	1
	Legal requirements: Sender realized during Preparations, that it would be more expensive to sell products Made in Spain to countries where EU had less favorable trade agreements than Norway. Nonetheless, Euro was more stable than the currency at their Chinese subsidiary and it was more advantageous to purchase from sub-suppliers within EU. Further, during one analysis early in the preparations phase, personnel with experience from previous transfers stressed the need to ensure comprehensive documentation for the transferred equipment and inventory, in order to avoid being stopped at the customs office, so several actions were implemented to reduce this risk.	2
	Financing: The cost of capital and land are evaluated as high, whereas the cost of inventory and the foreign exchange requirement are moderately appropriate.	3
	Geographical environment: The temperatures, humidity, air quality and geo-risk at the Spanish site are evaluated as moderately appropriate for electronics production.	2
	Sociopolitical environment: The area benefits of high governmental stability.	1
	Labor force: Workers' productivity and educational level at Receivers are evaluated as high and respectively moderate. Receiver's area was known for its material technology expertise and the labor force turnover was low. Yet, the workers' English skills were modest and this could be especially challenging during videoconferences.	2
	Culture: Workers are willing to assume responsibility and have an appropriate quality perception and problem solving approach. The relational closeness between job positions is moderate.	1
	Production environment: Receiver possessed the ISO 9001: 2008 certification within Quality management and achieved a good score when Sender conducted a Lean audit at their premises. Moreover, they were very receptive to new technologies and best practices. Nonetheless, when Sender's representatives visited them two months after kick-off, both parties realized how important it was to implement Sender's quality management systems and procedures in the new supply chain (for Change control, FIFO, tracing parts, the reception of sourced items, and for correct storage). In addition, they agreed on and took the first actions to implement Sender's ERP production module at Receiver. Receiver's personnel had to travel several times to Norway for training and the process required a trial period at Receiver, which could prolong the start-up and delay the steady state.	2
	R. to Supplier Relations	Distance: Sender and Receiver were part of the same corporation, yet the supply agreement they had was a buyer-supplier contract similar to the ones Sender had with external suppliers. This generated certain confusion among personnel. Sometimes, Sender's workers were hesitant to share information, whereas Receiver's workers expected more openness. The physical distances between the development and manufacturing of the core technology and the molding material were small, since the processes were collocated at Sender and respectively, Receiver. Yet, the fact that the two sites were located far from each other posed some characteristic challenges to their collaboration (e.g. if they will have to adapt technology to the Spanish market).
Power balance: The competition between Receiver and other 'receivers' that Sender could have selected is moderate, and the same applies for Sender and their competitors.		2
Motivation: Some of Sender's employees were afraid to lose their jobs in the future.		2

R. to Profit	Profit impact: The product volume is rather low, compared to Sender's other products. The products require a high amount of manual labor and are one of Sender's most price sensitive. Thus, Sender hopes to decrease the costs in the future due to the cheaper workforce (1/3 the cost at Sender) and to improve the products' robustness due to the new molding material. The outbound logistics could also decrease due to higher market proximity, but the inbound logistics could increase as long as Sender's original Norwegian suppliers are used.	2
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4 Discussion and Conclusion

In the previous section, we applied a conceptual framework developed from literature on a PT case. The framework was able to capture all the risk factors that had arisen during the PT process, suggesting its usefulness as a simple checklist for identifying and evaluating risk factors. When performing the assessment together with the Project owner and Sender's Quality & Risk manager, it was revealed that Sender and Receiver had identified some of the risk factors during the PT, and implemented actions for those on the way. For instance, as presented in Table 1, during one analysis early in the preparations phase, personnel who had been retained at the customs office for more than one day because of incomplete documentation stressed the need to validate the transportation documentation for equipment and inventory before transfer. Thereby, several actions were taken to avoid this scenario again. However, the PT parties had also encountered a series of unexpected events during the PT, which might negatively affect the performance results. For instance, a long time after the initial PT decision, Sender realized that there would be less favorable trade agreements when selling Made-in-Spain products to major customers overseas, compared to Made-in-Norway. The Receiver purchasing capital-intensive equipment more than one year prior to actual use is another example. If the PT parties had conducted the risk assessment early in the process, they could have implemented actions and avoided some of the pitfalls encountered. Moreover, we propose that the suggested assessment tool could be applied on several occasions, such as when the transfer object is selected (especially the 'factors related to transfer object'), when the location and receiver are selected ('factors related to receiver'), and when the PT plan is created (the entire list). A team with experienced members from key disciplines could jointly analyze possible unwanted events generated by each risk factor and rank them. Risk-mitigation actions should be considered for the factors in descending priority i.e., first for factors with high scores, etc. As [14,10] recommend, a cost-benefit evaluation should be conducted before choosing the actions. Thus, if the risk level is high, it is worth making high investments in e.g. expensive training, provided the profit impact is also high. Here one should also consider that it is recommended to rather prevent performance deviations than to correct them[16].

To conclude, we argue that the theoretical contribution of this study is the development of a conceptual framework based on a range of factors identified in literature, which seen through the risk management lens can be regarded as potential common risk factors in PTs. Moreover, the framework has been tested on a PT case together with experienced managers. Although a single case impedes the generalizability of the framework to other companies and industries, the empirical data is thoroughly collected during a period of 1 year, and it is reasonable to expect that part of the findings are applicable to other electronics producers and offshoring cases. Nonetheless, several types of PT cases should be studied and the PT risk assessment framework could be

validated through a survey. In this paper, the empirical data indicates that a structured assessment of risk factors during the early stages of PTs can aid practitioners in mitigating the PT risk, and thereby improve future performance.

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