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The impact of knowledge properties on international manufacturing transfer performance

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ABSTRACT

This paper examines how knowledge properties of a manufacturing activity transfer in international manufacturing network impact performance during the transfer itself and after steady state has been reached. Hierarchical regression was used to test the relationship on survey data from 178 companies. Knowledge properties as a group was significantly affected by both performance measures when controlling for the effects of sender unit experience, sender unit size and receiver unit experience. The activities transferred thus impact the success of the transfer. The control variables of sender unit experience and receiver unit experience have their relatively strongest performance effects after steady state has been reached. Independency was the single knowledge property dimensions with the strongest relative performance effect. This is one of the first survey studies to cover both the performance of the transfer itself and after reaching steady state of manufacturing transfers. Several strands of further research were therefore identified.

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Manufacturing transfer; offshoring; knowledge properties; knowledge context; knowledge management

1. Introduction

Today, multinational company groups commonly try to improve the efficiency of their manufacturing networks by relocating manufacturing activities between units (Golini and Petkova 2014; MacCarthy et al. 2016). These relocations are the result of decisions such as offshoring and backshoring (Kinkel 2012). However, carrying out these relocations is often associated with challenges (Vejrum Waehrens, Slepniov, and Johansen 2015; Fredriksson et al. 2015; Preast Knudsen and Madsen 2014).

Manufacturing relocation is not just a question of transferring hardware, such as equipment, systems or facilities. To utilise the transferred hardware effectively, knowledge needs to be transferred along with it (Cheng, Madsen, and Liangsiri 2010; Salomon and Martin 2008). Knowledge transfers involve both the sender's ability to capture and disseminate knowledge and the receiver's ability to absorb the same knowledge (Preast Knudsen and Madsen 2014; Szulanski 1996). The aim is to provide input to relocation decision-making processes (e.g. offshoring, outsourcing and backshoring) in manufacturing companies by highlighting the relationship between the knowledge transferred and the performance of the transfer.

In earlier studies, two types of performance measures have been generally considered. These mirror the two phases of a manufacturing transfer, i.e. physical transfer and start-up, and steady state. A steady state occurs when the new location, i.e. the receiver, has reached full-scale production at the targeted levels of cost, quality, volume and yield (Terwiesch and Bohn 2001). During start-up, the rate and yield are increased step-wise as knowledge of how to master the relocated activities is gradually incorporated among the employees of the receiver (Malm, Fredriksson, and Johansen 2016). Knowledge transfer in relation to a manufacturing transfer in most cases starts before the physical transfer and start-up and continues until the receiver masters the activities at the same level as the sender (Malm, Fredriksson, and Johansen 2016). Therefore, the success of a manufacturing transfer needs to assess both performances of the transfer itself and performance during steady state in order to cover the process as a whole. However, no study covering and comparing both performance measures has been identified. Some authors examine how well the transferred knowledge is retained and used by the receiving unit during steady state, e.g. the operational or economic performance of the firm (Lyles and Salk 1996), while others study the performance of the transfer itself, e.g. the time to volume or eventfulness of the transfer (e.g. Salomon and Martin 2008; Galbraith 1990; Stock and Tatikonda 2000; Szulanski 2000; Jensen and Szulanski 2004).

This study focuses on four dimensions of knowledge properties (complexity, independency, codifiability and knowledge requirement), which in previous studies have been

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shown to affect various aspects of transfer performance (e.g. Galbraith 1990; Zander and Kogut 1995). The purpose of this paper is to test the impact of knowledge properties on the two types of performances during manufacturing transfer (the performance of the transfer and start-up itself and of the activity after steady state is reached), controlling for the effects of properties of the sending and receiving units.

Pawar and Rogers (2014) found that there is a lack of research about what knowledge can be transferred between companies in a network as well as there is limited information about performance measures of knowledge transfer and how to use them. Furthermore, the lack in previous studies of consideration of the manufacturing transfer as a whole by clearly testing and comparing the performance effect during both the transfer itself as well as during steady state creates ambiguity on what impact different types of knowledge have on different phases of the transfer. It is highly relevant to look at these research gaps as multinational companies are becoming more footloose and increasing their number and frequency of relocations (Vejrum Waehrens, Slepniov, and Johansen 2015). Managing manufacturing transfers successfully is important to the competitiveness of these companies. Manufacturing transfers have previously been extensively studied in operations management research using case studies (Preast Knudsen and Madsen 2014; Fredriksson et al. 2015; Cheng, Madsen, and Liangsiri 2010; Grant and Gregory 1997a). Earlier studies of knowledge management in relation to manufacturing transfers are also relatively old (e.g. Galbraith 1990). Thus, to contribute to addressing the research gap identified by Pawar and Rogers (2014), to confirm case-based suggested relationships and to test the suggestions for example by Galbraith in the present-day context there is a need to present new survey studies. As this is one of the first studies to clearly compare the performances of different phases of a manufacturing transfer process, we also anticipate identifying several areas and strands for future research.

The following section defines the main variables and concepts, formulates eight hypotheses, and presents the conceptual model for the study. The methodology is then described and the analysis is conducted using survey data from a sample of Northern European manufacturing companies. Finally, the results are discussed, conclusions are drawn and suggestions for further research are presented.

2. Literature review and hypotheses

2.1. Transfer performance

Earlier studies that have examined the performance of the transfer, measure the progress of the start-ups at the receiver in two ways. First, they measure the time taken to reach a steady state (e.g. Salomon and Martin 2008; Galbraith 1990; Stock and Tatikonda 2000; Stock and Tatikonda 2008), because variance in this translates into economic consequences for firms (Salomon and Martin 2008) and the key goal of most transfers is to progress as quickly as possible. Second, they measure the difficulty of the transfer, because transfers that involve the most non-routine problems will be perceived as the most eventful and thus difficult, other things being equal (Szulanski 1996; Terwiesch and Bohn 2001; Jensen and Szulanski 2004). Here, we examine the difficulty of the transfer through the measure of eventfulness. Eventfulness is an interesting measure because manufacturing transfers introduce new risk sources (e.g. a new workforce, equipment or new sub-suppliers) that contribute to an increased risk of capacity and quality problems, which ultimately may cause events such as supply disruptions (e.g. Aaboen and Fredriksson 2016). These problematic events will require action in order to re-establish the ability to deliver, and for this reason, there is a high risk that the budget will be exceeded and expected benefits of the decision to transfer will not be reached (Almgren 1999; Terwiesch and Bohn 2001). An eventful start-up with a large number of problems increases the time and costs of reaching the steady state. Therefore, studying the eventfulness of a transfer provides guidance on the cost and the time spent to accomplish the physical transfer and start-up. Furthermore, problematic events are remembered because participants' expectations of the transfer were not met (Szulanski 1996; Jensen and Szulanski 2004).

Performance of the manufacturing transfer after the steady state has been reached is seen as the performance of the activity at the receiving unit (i.e. the new physical location). Studies of performance, after steady state has been reached, have mainly been within the knowledge management discipline and have not considered knowledge transfer in conjunction with a transfer of manufacturing activities. These studies have measured the receiver's ability to use the knowledge transferred to create and augment its competitive capabilities (Lyles and Salk 1996). This has been done from two perspectives (Van Wijk, Jansen, and Lyles 2008): in terms of economic and business criteria (e.g. Lyles and Salk 1996; Dhanaraj et al. 2004) and in terms of speed of knowledge diffusion (e.g. Zander and Kogut 1995). Here, we examine the economic and business criteria. These can be measured in many ways, e.g. business volume growth, achieving planned goals, productivity, unit costs, overhead costs and profitability (Lyles and Salk 1996).

2.2. Properties of sending and receiving units

Previous literature recognises that absorptive capacity (i.e. the ability of the receiving unit to recognise the value of new knowledge and to retain it) is a key factor in successful knowledge transfer (Cohen and Levinthal 1990; Easterby-Smith, Lyles, and Tsang 2008). The absorptive capacity is often described as the recipient's knowledge prior to transfer, i.e. its experience (Szulanski 1996; Galbraith 1990; Ferdows 2006). The experience of a receiver is dependent on several things; however, a greenfield (start-up) receiver in most cases has less experience than an existing receiver (brownfield). For example, Cheng, Madsen, and Liangsiri (2010) find that greenfield sites have less absorptive capacity than brownfield sites, and Madsen (2009) showed that greenfield sites lack experience of how to deal with problems. Oppat (2008), Whitehead, Zacharia, and Prater (2016) and Tang, Mu, and Maclachlan (2010) all state that the senders' disseminative capacity is just as important as the receivers'

Table 1. Summary of studies empirically testing the relationship between knowledge properties and transfer performance.

Authors	Studies covering performance impact of knowledge dimensions on the transfer itself	Studies covering performance impact of knowledge dimensions during steady state, i.e. during knowledge dissemination
Galbraith (1990)	Complexity has a negative impact on loss, time to recovery and success of the transfer. Age has a positive impact on loss and success, but negative impact on recovery.	–
Salomon and Martin (2008)	Complexity (relative feature size) has a negative impact on time to build and cost.	–
Stock and Tatikonda (2008)	Technology uncertainty has a negative impact on the budget, schedule and function of the technology acquired from outside the firm.	–
Teece (1977)	Ambiguity has a negative impact on costs of transfer. Lower age has a negative impact on transfer costs.	–
Szulanski (1996),	Unproven knowledge has a minor impact on stickiness. Causal ambiguity is a major barrier to transfer and increases stickiness.	–
Szulanski (2000)	Unproven knowledge increases stickiness at the beginning of the transfer process. Causal ambiguity increases stickiness throughout the transfer process.	–
Jensen and Szulanski (2004)	Causal ambiguity increases stickiness.	–
Zander and Kogut (1995)	–	Codifiability improves speed of transfer. Teachability improves speed of transfer. Complexity has no impact on speed of transfer. Independency has no impact on speed of transfer.
Dhanaraj et al. (2004)	–	Tacit knowledge has a negative impact on international joint-venture (IJV) performance. Explicit knowledge has a positive impact on IJV performance.
Van Wijk, Jansen, and Lyles (2008)	–	Knowledge ambiguity has a hampering impact on knowledge transfer, both within and between companies.

absorptive capacity. Experience of previous knowledge transfers and firm size are important properties of the sending unit's disseminative capacity (Van Wijk, Jansen, and Lyles 2008; Gerbl, Mcivor, and Humphreys 2016). To improve transfer performance, the sending organisation needs to prepare carefully before entering a project management mode of transferring knowledge (Preast Knudsen and Madsen 2014). Haleblian and Finkelstein (1999) conclude that firms executing several similar knowledge transfers within the same industry can benefit from earlier experience as experience of previous transfers helps organisations to organise transfers more effectively (Szulanski 2000). The firm size of the sending unit affects the ability to transfer knowledge because larger firms have more resources and more diverse knowledge reservoirs to devote to transfers (Van Wijk, Jansen, and Lyles 2008). However, in previous studies there are mixed results for the impact of size; where some see positive effects, others see no effects and others again see negative effects (Van Wijk, Jansen, and Lyles 2008).

2.3. Knowledge properties of the activity transferred and hypothesis development

The properties of the knowledge can be described based on a set of knowledge dimensions (Winter 1987). Different dimensions of knowledge differ in the ease with which they can be replicated and applied by the receiving unit (Ferdows 2006; Stock and Tatikonda 2000; Van Wijk, Jansen, and Lyles 2008). Ambiguity, how well the knowledge is understood (Szulanski 1996; Szulanski 2000; Teece 1977; Van Wijk, Jansen, and Lyles 2008) and the novelty of the technology are commonly used dimensions to describe knowledge (e.g. Galbraith, 1990; Szulanski, 1996; Szulanski 2000; Teece 1977). Winter (1987) presents another four dimensions less abstract than ambiguity, describing the properties of transferred knowledge: articulability, complexity, independency and observability. Zander and Kogut (1995), based on Winter's (1987) dimensions, use the dimensions of codifiability, teachability, complexity and independency to test how quickly innovative technologies are transferred to other companies. Earlier empirical studies, testing the relationship between knowledge property dimensions and transfer performance are summarised in Table 1.

From Table 1 it can be seen that earlier studies have focused on either knowledge transfers in relation to the transfer itself or knowledge dissemination during steady state. Earlier studies of steady state (Table 1, column 3) have focused on certain types of knowledge and how quickly this knowledge moves between companies: Zander and Kogut (1995) study how quickly an innovation spreads between companies, Dhanaraj et al. (2004) focus on how knowledge spreads within international joint ventures, and Van Wijk, Jansen, and Lyles (2008) use a meta-analytical approach studying earlier studies of knowledge transfers. Thus, none of these studies has included any type of manufacturing activity transfer and start-up. On the other hand, earlier studies of the transfer itself (column 2, Table 1) have included transfers of activities or products. Here, Szulanski (1996), Szulanski (2000), and Jensen and Szulanski (2004) all studied the stickiness of transfer and Stock and Tatikonda (2008) the importance of context and interaction between organisations. Salomon and Martin (2008), Teece (1977) and Galbraith (1990) all studied manufacturing transfers, focusing, however, on measuring time and the cost of reaching the steady state. Thus eventfulness has not been measured in relation to physical transfer and start-up of a manufacturing transfer. Furthermore, manufacturing transfers have been regarded as finished when steady state has been reached. Successful outsourcing and offshoring decisions nevertheless imply that the receiver utilises the transferred activities in such a way that the goals of cost-cutting and/or quality improvements are attained (Fratocchi et al. 2014; Kinkel 2012; Kinkel and Maloca 2009). Therefore, to increase knowledge of how to accomplish successful outsourcing and offshoring decisions there is a need for studies considering manufacturing transfer as a whole.

The knowledge property dimensions studied in this paper (codifiability, independency, knowledge requirement and complexity) are introduced below, together with the generation of the hypotheses. This study measures the performance of the transfer itself as the 'eventfulness', i.e. the greater the eventfulness the lower the performance of the transfer itself. Performance after reaching of steady state is measured as productivity and profitability. We expect all four studied knowledge property dimensions to affect both performance measures.

Codifiability captures the degree to which knowledge can be encoded, i.e. its level of tacitness (Edmondson et al. 2003). Tacit knowledge is difficult to describe in a way that is helpful for another person. Explicit knowledge, on the other hand, can be codified and expressed in documents and manuals (Ferdows 2006). Earlier research is in agreement that codifiable knowledge is more easily transferred than non-codifiable knowledge (Ferdows 2006; Grant and Gregory 1997b; Dhanaraj et al. 2004; Zander and Kogut 1995; Edmondson et al. 2003). The positive impact of codifiable knowledge on performance may be due to its clarity, relatively low transfer cost, and the applicability of associated routines (Dhanaraj et al. 2004). Therefore:

H1a. During the transfer itself the codifiability of the transferred activity reduces eventfulness.

H2a. After reaching steady state, the codifiability of the transferred activity improves the performance of the activity.

Manufacturing transfers cause firms to enter into interdependencies (Nassimbeni 1998; Vejrum Waehrens, Slepniov, and Johansen 2015) in which some transferred activities are closely linked to other activities remaining in the sending unit so that the independency of the units decreases. *Independency* is the opposite of dependency, which captures the degree to which a capability is dependent on many experienced people for its production (Zander and Kogut 1995). Thus, independency is the extent to which the transferred activity is dependent on activities, processes and knowledge still within the sender after the transfer. Low independency requires effective coordination (Nassimbeni 1998) and reciprocal knowledge transfer between the sending and receiving units (Kohlbacher and Krähe 2007). Low independency, in which the transferred activity needs considerable input from several sending unit sources, has been found to diminish transfer performance (Zander and Kogut 1995), and may increase start-up time (Aaboen and Fredriksson 2016) and create cost overruns (Hui, Davis-Blake, and Broschak 2008). Therefore:

H1b. During the transfer itself the independency of the transferred activity reduces eventfulness.

H2b. After reaching steady state, the independency of the transferred activity improves the performance of the activity.

A knowledge dimension relevant in the context of international manufacturing transfers is *knowledge requirements*. Knowledge resides within the user and is dependent on how the user reacts when coming across new knowledge (Pawar and Rogers 2014). For example, to be efficiently run, newly developed products and their production processes usually require knowledgeable employees (Grant and Gregory 1997b). To find knowledgeable employees within a receiver is especially pertinent in manufacturing transfers, as these often occur from Western to low-cost countries, where human capital and skilled labour (i.e. abilities) may be lacking (Handfield and McCormack 2005) and capabilities are more variable (Schoenherr et al. 2012). Szász, Scherrer, and Deflorin (2016) show that there is a difference between the ability to increase efficiency by integrating knowledge from the manufacturing network between companies in highly and less developed countries. Knowledge requirements are the demands the transferred activity make on the existing knowledge of the individual employees of the receiver (Szulanski 1996; Galbraith 1990; Ferdows 2006). A user with more experience, i.e. knowledge accumulated over time by handling regular production flows and malfunctions as they occur (Preast Knudsen and Madsen 2014), is more knowledgeable. If there is a high level of knowledge requirements for the receiver's employees through the knowledge related to the transferred activities, this should diminish transfer performance. Therefore:

H1c. During the transfer itself the knowledge requirement of the transferred activity increases eventfulness.

H2c. After reaching steady state the knowledge requirement of the transferred activity reduces the performance of the activity.

In relation to knowledge, *complexity* measures the inherent variations in combining different kinds of competencies (Zander and Kogut 1995), i.e. the higher the number of different elements that compromise the body of knowledge, the more complex the knowledge (Minguela-Rata, Rodríguez-Enavides, and López-Sánchez 2012). Thus, the higher the complexity of the knowledge, the more knowledge sources are needed (Cheng, Madsen, and Liangsiri 2010). Gerbl, Mcivor, and Humphreys (2016), based on case studies, have found that processes where extensive specialised knowledge and experiences are combined, i.e. where there is high knowledge complexity, make knowledge transfer more difficult. Complexity slows the learning process (Galbraith 1990; Cheng, Madsen, and Liangsiri 2010; Salomon and Martin 2008), requires more sophisticated training (Cheng, Madsen, and Liangsiri 2010), and demands more of information processing (Stock and Tatikonda 2000) as several types of knowledge and knowledge sources have to be identified and added together. Therefore:

H1d. During the transfer itself, the complexity of the transferred activity increases eventfulness.

H2d. After steady state has been reached, the complexity of the transferred activity reduces the performance of the activity.

Unit property relationship dimensions are included as control variables (Hypothesis 1 and 2). Eventfulness is also expected to affect performance after reaching of steady

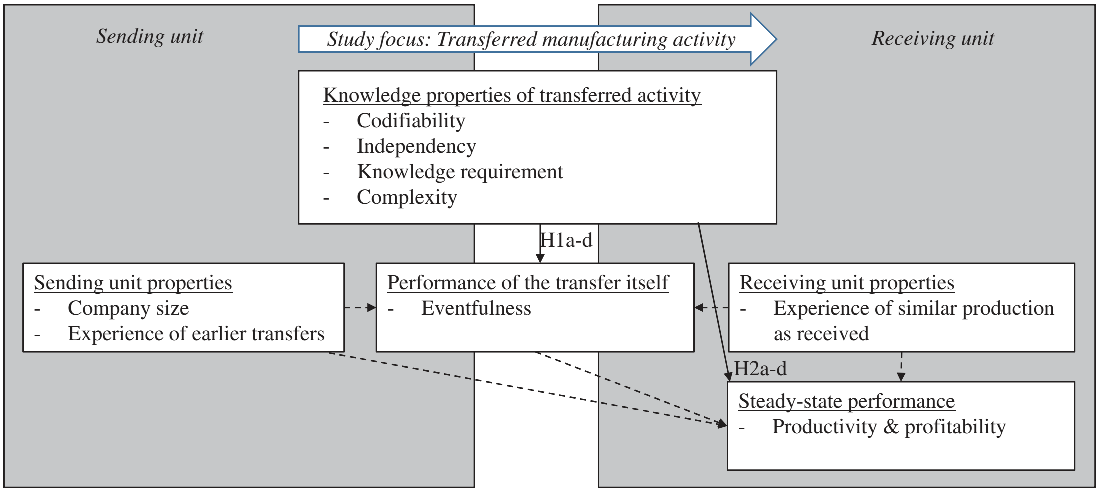

Figure 1. Conceptual relationships between knowledge management context variables and transfer performance.
Note: Solid arrow = hypothesized relationship, dashed arrow = control variable relationship.

state. Therefore, eventfulness is also included as a control variable when testing the steady-state performance effects (Hypothesis 2a–d). Figure 1 illustrates the proposed conceptual relationships between our knowledge management context and performance variables.

3. Methodology

3.1. Sample

The study population comprised of Swedish and Danish manufacturing firms with over 50 employees. Addresses were obtained from the Experian.dk database (resulting in 2900 Danish companies, 800 of which were manufacturing companies) and the Swedish postal service database (resulting in 1549 Swedish manufacturing companies). Questionnaires were sent to all 4449 firms; 978 completed questionnaires were returned, giving a response rate of 22%. Of these returned questionnaires, 194 were from companies (87 Swedish and 107 Danish) that had transferred manufacturing activities. Of these 194 companies, 16 had transferred manufacturing support activities, such as maintenance and quality assurance; these were excluded, as this study concentrates on direct production activities (e.g. manufacturing and assembly). The total number of responses used in the analysis is consequently 178.

The addressee of the questionnaire was the CEO or plant manager. The unit of analysis is the plant level and the plant's most recent manufacturing activity transfer event as a sender; respondents were asked to focus on this event and its implications when completing the survey. As the focus of this paper is the latest manufacturing transfer and the knowledge related to this, both transfers within the network (offshoring) as well as within the supply chain (outsourcing) were considered. Non-response bias was tested for by comparing independent and dependent variables between early and late survey responses (*t*-tests for interval-scaled items and Chi-square tests for nominally scaled items). No significant ($p < .05$) difference was identified, so these tests indicate no non-response bias.

Table 2 describes the characteristics of the sample, which contains a wide spread between small and large firms. The sample also covers all manufacturing firms in two countries. Including all manufacturing firms in the sample reduces the risk of bias in relation to certain types of industry. Including two countries reduces the risk of bias due to the specific characteristics of the country. However, as the countries are two small countries in Northern Europe they may still have several similarities, which may increase the risk of bias.

3.2. Measurement instrument

The questionnaire was jointly developed by researchers in a programme involving Swedish and Danish universities. The questionnaire was pre-tested in Denmark and in Sweden by four academics with experience of offshoring and manufacturing transfers, and by four experienced CEOs and plant managers. Based on the pre-testing, some questions were reformulated to be more straightforward, and the wording was changed to reduce the risk of misinterpretations. Furthermore, some questions were removed to reduce the numbers of questions. The online questionnaire was distributed by e-mail, first in Denmark in autumn 2011 and then in Sweden in spring 2012. Two e-mail reminders were sent, and the respondents were also phoned.

As far as possible, the survey instrument was based on previously used operationalisations of constructs. These were identified through a review of relevant literature in the areas of knowledge management and operations management. A first search, searching on the words manufacturing transfer, production transfer and knowledge transfer were made using Google Scholar. Relevant papers were identified by scanning abstracts. The citation pearl growing method of Rowley and Slack (2004) was then followed to identify further papers from the papers identified as relevant. Given the focus and purpose of this study, no previously used measure could be used without modification. The following three groups of constructs were used: (1) transfer performance, (2) knowledge properties and (3) properties of the units. Most constructs were measured as multi-item measures using seven-

Table 2. Description of sample characteristics.

Item	Measure
Number of full-time employees globally at company level	Mean (std. dev.): 2888 (7917) Median (quartiles): 275 (110, 1200)
Percentage of total employees employed domestically at company level	Mean (std. dev.): 49.7 (32.7) %
Number of countries with manufacturing activities at company level	Mean (std. dev.): 12 (22.3) Median (quartiles): 4 (2, 12)
Number of countries where activities have been transferred at company level	Mean (std. dev.): 3.3 (3.0) Median (quartiles): 2 (1,4)
Have an overall strategy guiding activity transfer at company level	113 (60%)
Type of plant making transfer (sender)	Parent company: 73 (48%) Subsidiary of a non-domestic corporation: 58 (34%) Subsidiary of a domestic corporation: 22 (13%)
Type of plant receiving transfer	Subsidiary: 103 (64%) Independent supplier: 47 (29%) Joint venture: 12 (7%)
Type of plant receiving transfer	New: 51 (31%) Existing: 114 (69%)
Location of the plant receiving transfer	Eastern Europe: 77 (43%) Southeast Asia incl. China: 58 (32%) Western Europe: 23 (13%) North America: 5 (3%) Other Asia: 8 (5%) South/Latin America: 5 (3%) Unspecified: 2 (1%)

point Likert scales (see Appendix A for individual items and scales). The firm size was measured as the natural logarithm of the number of employees, and the receiver's experience was measured as a dummy variable. The natural logarithm of size is introduced as it produces a regression curve that is closer to linear than the original size variable. This transformation is consistent with other operations management studies based on linear regression models (e.g. Boyer et al. 1997).

3.2.1. Transfer performance variables

We considered two types of transfer performance: (1) performance of the transfer itself and (2) performance after steady state has been reached. The performance of the transfer itself was measured as eventfulness, events being defined as remembered occurrences (Szulanski 1996; Jensen and Szulanski 2004). Eventfulness is a relevant measure as it has a universal base case: a start-up that is not at all problematic is un-eventful (Szulanski 1996). The more eventful a transfer has been, the more problematic it is likely to be remembered as being. Therefore, eventfulness of a transfer and its magnitude is likely to be recalled for historical transfers of those involved in the transfer. The eventfulness scale was based on Szulanski's (1996) 'stickiness-process-based measures.' However, Szulanski's (1996) scales focused on the various steps of the process and are very detailed; instead, we wanted to measure the overall perceived eventfulness of the transfer and hence aggregated four of Szulanski's measures.

To measure performance after reaching steady state, our starting point is steady-state production as defined in the production start-up literature. A steady state occurs when a new location has reached full-scale production at the targeted levels of cost, quality, volume and yield (Terwiesch and Bohn 2001), i.e. the intended productivity. Because productivity levels are normalised when steady state has been reached, it should be a relevant measurement item for the retention of transferred knowledge related to hardware operations. To capture the overall economic dimensions of transfer performance, profitability is used as a second measurement item of performance after steady state has been reached (Palepu 1985). Consequently, performance, after steady state has been reached, is measured with a Likert scaled two-item construct (measuring productivity and profitability).

3.2.2. Knowledge property variables

Knowledge property dimensions were measured using four scales, three of which (codifiability, independency and complexity) were developed from the Zander and Kogut (1995) scales. Zander and Kogut (1995) measured more organisational capabilities, whereas we emphasise the knowledge properties of an activity (i.e. product or manufacturing process). Therefore, the questions had to be reformulated to fit with this context. Our independency construct concerns the activity in relation to the sender's activities and was measured as a single-item construct. The other knowledge property constructs were measured with multi-item constructs. The scale used to measure knowledge requirements was developed based on the 'recipient lacks absorptive capacity' scale of Szulanski (1996). However, Szulanski (1996) used nine items while we originally used three, as we wanted to measure only the demands on prior knowledge of the transferred activity on individuals at the receiver and not the receiver's organisational capabilities.

3.2.3. Properties of the units variables

We used the sender's experience of earlier knowledge transfers, sender firm size and receiver's experience of earlier production in similar areas as measures of these variables. Previous sender experience of knowledge transfer scale was developed from Szulanski (1996), which measures the sender's planning and documentation of the transfer. Sender size was measured using a single measure, i.e. number of sender employees. The receiver's experience was measured using a single measure, i.e. whether the receiver was a greenfield (start-up) or brownfield (existing) site. This measure was based on the finding of Cheng, Madsen, and Liangsiri (2010) that greenfield sites have less absorptive capacity than brownfield sites due to lack of experience and necessary support systems.

Size, receiver's experience and independency are, consequently, measured as single-item measures. Bergkvist and Rossiter (2007) argue that single-item measures are acceptable when (1) the object of the construct is 'concrete singular,' meaning that it consists of one object that is easily and uniformly imagined, and (2) the attribute of the construct is 'concrete,' again meaning that it is easily and uniformly imagined. This is the case for our size measure. For the receiver's experience, we measure whether the receiving site is new or pre-existing. For independency, we measure to what extent the activity, in general, is independent of the sender's activities. Consequently, for both measures, we measure the key construct, but the lack of including more dimensions is a limitation.

3.3. Measurement validity and reliability

The descriptive statistics for each item measured on 7-point Likert scale are presented in Table 3. The following item abbreviations are used in the tables: sender's experience (SEXP), codifiability (COD), independency (INDEP), knowledge requirements (KNOW), complexity (COMP), eventfulness (EVENT), performance during steady state (PERF).

The literature review identifying definitions and descriptions of concepts, the pretesting of the survey with business executives and researchers and the follow-up discussions with these individuals established the basis for the content validity of the survey instrument.

The reliability and construct validity of all multi-item scales were first evaluated using exploratory factor analysis (Table 4). All knowledge property, unit property and performance items were included in one-factor analysis. It is recommended that exploratory factor analysis be used for scales early in their development (Hurley et al. 1997), which was the case for all our scales. During the factor analysis, we identified three items which did not have high loadings on a single factor. These three items belonged to the codifiability and complexity constructs. The remaining items of these constructs were considered to define the respective construct even if excluding the three items. Therefore, these items were excluded from the scales. The results presented in Table 4 exclude the items and validate all tested constructs. In the final factor analysis model, each item is loaded heavily onto one of six single factors with minimal cross-loading (Table 4).

Two approaches were used to measure reliability. First, for all constructs with more than two items internal consistency was supported by acceptable Cronbach's α values for new scales (above 0.6) (Nunnally and Bernstein 1994). Spearman–Brown coefficients were calculated for scales with two items (Eisinga, Grotenhuis, and Pelzer 2013). The complexity construct items showed lowest coefficient (r = 0.56), which is just below the 0.6 cut-off for new scales. Second, the corrected item-total correlation (CITC) reliability test was used (Kerlinger 1986). The CITCs of all items in the same construct are greater than 0.3, the lowest acceptable value (Kerlinger 1986). All these measurement scales are considered reliable because all Cronbach's αs, all but one Spearman–Brown coefficients and all CITC values are acceptable for exploratory research (Hair et al. 2010). Complexity is the construct with the weakest CITS and a Spearman–Brown coefficient just below 0.6, but we consider it to be conceptually strong as the number of sub-processes and creativeness/innovativeness are two complementary complexity dimensions. The two types of complexity drivers do not necessarily have to occur at the same time, which may explain the relatively modest correlation between items in the same construct.

Note: For item names and measures, see Appendix A. Principal component analysis with varimax rotation;

Table 3. Means and standard deviations of all Likert-scaled items.

Item	Number of responses	Mean	Std. dev.
SEXP1	149	5.20	1.72
SEXP2	148	4.16	1.78
SEXP3	148	4.58	1.50
COD1	154	5.08	1.17
COD2	154	4.65	1.51
INDEP	159	3.99	1.85
KNOW1	156	5.17	1.41
KNOW2	156	3.20	1.57
KNOW3	153	4.19	1.85
COMP1	157	4.72	1.52
COMP2	155	3.13	1.51
EVENT1	152	3.37	1.68
EVENT2	151	3.46	1.62
EVENT3	151	3.58	1.66
EVENT4	148	3.49	1.53
PERF1	149	4.88	1.31
PERF2	150	5.53	1.13

Note: For item names and measures, see the Appendix A.

Table 4. Exploratory factor Analysis and CITC of items.

	Component						
Item	1	2	3	4	5	6	CITC
COD1	−0.01	0.16	0.16	0.06	**0.76**	0.08	0.47
COD2	−0.06	0.16	0.09	0.15	**0.79**	−0.03	0.47
INDEP	−0.24	0.03	0.04	0.50	−0.38	−0.10	–
KNOW1	−0.04	0.00	**0.79**	−0.17	−0.15	−03	0.51
KNOW2	0.03	0.08	**0.73**	0.23	−0.12	−0.04	0.39
KNOW3	−0.01	−0.03	**0.69**	−0.02	0.24	0.18	0.49
COMP1	0.03	−0.06	0.00	0.12	−0.03	**0.87**	0.39
COMP2	0.21	0.18	0.20	−0.17	0.11	**0.74**	0.39
SEXP1	−0.09	**0.68**	0.00	0.09	0.20	0.18	0.51
SEXP2	−0.08	**0.84**	−0.08	0.14	0.24	0.09	0.71
SEXP3	0.15	**0.81**	0.13	0.00	−0.07	−0.18	0.49
EVENT1	**0.93**	−0.01	−0.09	−0.02	0.00	0.05	0.86
EVENT2	**0.92**	−0.03	−0.04	−0.16	0.00	0.12	0.88
EVENT3	**0.92**	−0.06	0.04	−0.08	−0.04	0.04	0.86
EVENT4	**0.90**	0.07	0.06	−0.06	0.00	0.04	0.70
PERF1	−0.04	0.27	−0.11	**0.71**	0.30	−0.06	0.51
PERF2	−0.11	−0.01	0.08	**0.86**	0.14	0.10	0.51
Eigenvalue	1.10	1.31	2.79	1.09	3.73	1.86	–
Reliability (α, r)	α = 0.94	α = 0.72	α = 0.62	r = 0.67	r = 0.64	r = 0.56	–

Note: For item names and measures, see appendix. Principal component analysis with varimax rotation; cumulative % variance explained = 71.3%; bold values indicate the factor loadings of each item on its intended construct. Cronbach's alpha (α) and Spearman-Brown coefficient (r) values concern constructs based on items in bold. CITC values refer to the items in the respective constructs.

cumulative % variance explained = 71.3%; bold values indicate the factor loadings of each item on its intended construct. Cronbach's α and Spearman–Brown coefficient (r) values concern constructs based on items in bold. CITC values refer to the items in the respective constructs.

Secondly, a confirmatory factor analysis was conducted to test the convergent and discriminant validity of the multi-item constructs generated from the exploratory factor analysis. The model yielded an acceptable overall fit (Chi-square/df = 1.82; RMSE = 0.06; CFI = 0.92; NFI = 0.85) according to Hair et al. (2010). All unstandardised factor loadings were

Table 5. Confirmatory factor analysis.

	Component					
Item	COD	KNOW	COMP	SEXP	EVENT	PERF
COD1	0.68	–	–	–	–	–
COD2	0.69	–	–	–	–	–
KNOW1	–	0.66	–	–	–	–
KNOW2	–	0.46	–	–	–	–
KNOW3	–	0.77	–	–	–	–
COMP1	–	–	0.61	–	–	–
COMP2	–	–	0.66	–	–	–
SEXP1	–	–	–	0.68	–	–
SEXP2	–	–	–	0.76	–	–
SEXP3	–	–	–	0.71	–	–
EVENT1	–	–	–	–	0.90	–
EVENT2	–	–	–	–	0.92	–
EVENT3	–	–	–	–	0.89	–
EVENT4	–	–	–	–	0.85	–
PERF1	–	–	–	–	–	0.83
PERF2	–	–	–	–	–	0.47
AVE	0.47	0.41	0.42	0.51	0.80	0.46
CR	0.64	0.67	0.59	0.73	0.94	0.61

Note: values indicate the unstandardized factor loadings. AVE = average variance extracted and CR = composite reliability (Hair et al.2010).

Table 6. Cross-construct loadings.

	Component					
Item	COD	KNOW	COMP	SEXP	EVENT	PERF
COD	**0.69**	–	–	–	–	–
KNOW	0.31	**0.64**	–	–	–	–
COMP	0.04	0.23	**0.65**	–	–	–
SEXP	0.53	0.14	0.13	**0.71**	–	–
EVENT	0.10	0.03	0.22	0.08	**0.89**	–
PERF	0.30	0.21	0.06	0.46	0.13	**0.67**

Note: Diagonal values (**bold**) are the square root of the AVE for each construct. Off-diagonal values demonstrate bi-variate correlations.

statistically significant (p < 0.01) as required for convergent validity (Table 5). Two (KNOW2 and PERF2) standardised factor loadings were slightly lower than .5 and several were in the 0.6 to 0.7 range, resulting in CR values around 0.6 for the COMP and PERF constructs and AVEs around 0.4 for KNOW and COMP. All the other CRs were around 0.7 or higher and the AVEs were around 0.5 or higher (i.e. around or above suggested limits according to Bagozzi and Yi 1988 and Hair et al. 2010).

Table 6 shows that each construct's square root of AVE is larger than the respective construct's correlation with each of the other constructs (latent variables) in the confirmatory factor analysis model, i.e. indicating an adequate level of discriminant validity.

Table 7 presents the bivariate correlations for each item included in constructs or as single items in the regression analyses. Some cross-loadings and correlations between items in different independent constructs emerged. The strongest bivariate correlations between items in different independent variable constructs were COMP2's correlation with KNOW1 (r = 0.25) and KNOW3 (r = 0.29), as well as the correlations of two experience items (SEXP1 and SEXP2) with the two codifiability items (r between 0.24 and 0.37). These cross-loadings may explain the lower AVEs for COMP and KNOW. We do not, however, infer that these correlations and AVEs indicate serious discriminant validity problems for this study. For example, a creative and innovative activity (COMP2) requires experienced (SEXP1) and trained (SEXP3) personnel. A company with experience from transfers (SEXP1) and documented transfers (SEXP3) clearly defines (COD1) and sets goals (COD2) for the transferred activity. These cross-construct item correlation coefficients are nevertheless not very high. Large correlations between single items across constructs also indicate a potential multi-collinearity problem, but the variance inflation factor (VIF) values of all independent variables examined in the 'Analysis and Results' section indicate that this should not be a problem. The fact that we test blocks of variables in hierarchical regression models should also reduce this risk.

Finally, we checked for common method bias using Harman's single factor test and the latent factor test

Table 7. Bi-variate correlations (Pearson) of dependent and independent variables.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. SIZE	0.21**	0.05	0.04	0.13	0.04	0.00	0.10	0.20*	0.09	0.05	0.01	−0.06	−0.09	0.03	−0.08	0.00	0.01
2. SEXP1	–	0.59**	0.28**	0.24**	0.25**	−0.01	0.02	−0.01	0.09	0.04	0.12	−0.03	−0.07	−0.07	−0.02	0.20*	0.17*
3. SEXP2	–	–	0.53**	0.28**	0.37**	−0.03	−0.10	−0.01	0.04	0.04	0.13	−0.09	−0.11	−0.10	−0.07	0.34**	0.16
4. SEXP3	–	–	–	0.14	0.10	0.00	0.05	0.08	−0.02	−0.14	0.12	0.08	0.09	0.07	0.18*	0.21*	0.00
5. COD1	–	–	–	–	0.47**	−0.10	0.16*	0.07	0.14	0.13	0.10	−0.08	−0.06	−0.03	−0.01	0.14	0.10
6. COD2	–	–	–	–	–	−0.05	0.04	0.02	0.14	0.07	0.02	−0.06	−0.06	−0.10	−0.08	0.20*	0.21*
7. INDEP	–	–	–	–	–	–	−0.03	0.00	−0.04	−0.04	−0.19*	−0.18*	−0.24**	−0.22**	−0.21**	0.10	0.20*
8. KNOW1	–	–	–	–	–	–	–	0.31**	0.45**	0.01	0.25**	−0.04	−0.02	0.02	0.00	−0.07	−0.05
9. KNOW2	–	–	–	–	–	–	–	–	0.29**	0.07	0.08	−0.09	−0.08	0.01	0.06	0.01	0.09
10. KNOW3	–	–	–	–	–	–	–	–	–	0.06	0.29**	−0.02	0.00	0.06	0.03	−0.01	0.04
11. COMP1	–	–	–	–	–	–	–	–	–	–	0.35**	0.04	0.05	0.05	0.06	−0.06	0.11
12. COMP2	–	–	–	–	–	–	–	–	–	–	–	0.22**	0.32**	0.25**	0.23**	−0.03	−0.09
13. EVENT1	–	–	–	–	–	–	–	–	–	–	–	–	0.85**	0.79**	0.73**	0.02	−0.09
14. EVENT2	–	–	–	–	–	–	–	–	–	–	–	–	–	0.81**	0.77**	−0.08	−0.21**
15, EVENT3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.78**	−0.12	−0.15
16. EVENT4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	−0.11	−0.14
17. PERF1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.50**
18. PERF2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note: For item names and measures, see appendix. Receiver's experience with Dummy variable scale is not included. $^{*}p < .05$; $^{**}p < .01$.

Table 8. Regressions for the performance of the transfer itself (Eventfulness).

Dependent variable: performance of the transfer itself (Eventfulness)		
Independent variables	Model 1 Beta	Model 2 Beta
Step 1: Control variables		
Company size	0.01	0.02
Sender's experience	−0.03	−0.01
Receiver's experience	−0.25***	−0.21**
Step 2: Knowledge property variables		
Codifiability	–	−0.10
Independency	–	−0.24***
Knowledge requirements	–	0.02
Complexity	–	0.13
R^2	0.06	0.15
Changes of R^2	–	0.09
F-value of change of R^2	2.88**	3.02**
F-value	2.88**	3.04***

Note: *$p < .10$; **$p < .05$; $p < .01$***.

(Podsakoff et al. 2003). Harman's test showed that the variance explained by a single factor in a non-rotated exploratory factor analysis including all items was 12.05%. The latent factor test, where the factor loadings of a confirmatory factor analysis model with an added latent variable were compared with those of the original measurement model, showed no loss in significance of the factor loadings. Consequently, these tests did not indicate any common method bias.

4. Analysis and results

Hierarchical linear regression was used for the analysis. Three hierarchical regression models (each including two groups of variables entered as blocks in two steps) were generated to test the hypotheses: one with performance of the transfer itself (i.e. eventfulness) as the dependent variable and two with performance after reaching steady state (i.e. productivity and profitability) of the transferred activity as the dependent variables. Two groups of variables (i.e. control and knowledge property variables) were used in all models. The performance of the transfer itself (i.e. eventfulness) variable was included in the block of control variables in the last two sets of regression models. Each group of variables was entered as a block, and in a purposeful sequence, into the regression models. This identifies the incremental predictive power of the group of knowledge property variables when controlling for sender firm size, sender experience, receiver's experience, and eventfulness. Multi-collinearity was assessed by examining the variance inflation factor (VIF) of each independent variable. The highest VIF for the eventfulness model was 1.43 and for the five performance models was 1.48, so all VIFs in both models were below the suggested values (Hair et al. 2010).

4.1. Effect on the performance of the transfer itself

The first analysis treats the performance of the transfer itself (i.e. eventfulness) as the dependent variable presented in Table 8. We hypothesised that the knowledge properties of the transfer activity would affect the level of eventfulness during start-up, where codifiability (H1a) and independency (H1b) would have significant negative impacts, and complexity (H1c) and knowledge requirement (H1d) significant positive impacts, at the level of eventfulness.

Adding the first block of control variables results in a significant regression model ($p < .05$). The receiver's experience, measured as moving to a brownfield site, had a significant negative effect on eventfulness. This means that moving to an existing site results in less unexpected challenges during start-up compared to a new site. The knowledge property dimensions, added as block 2, collectively explain a significant additional proportion of the variance in the performance of the transfer itself (i.e. eventfulness) variable, above that explained by the control variables ($R^2 = 0.15$). The independency ($p < .01$) variable was the knowledge property variable being statistically significant in this model. As expected, the beta values of codifiability and independency were negative and the value of complexity was positive. *This verifies H1b, but rejects H1a, c and d because of lack of significance.*

4.2. Effects on performance after transferred activity reaches steady state

The second analysis considers the performance of the transferred activity after steady state is reached, presented in Table 9. It was hypothesised that the knowledge properties of the transferred activity (H2a–d) would significantly affect its performance after steady state has been reached. The generally hypothesised positive and negative impacts of the individual variables were opposite those in H1 and in the related regression model with performance of the transfer itself as the dependent variable.

We used the same blocks of independent variables, and sequence of entering them, as in the regression model for the performance of the transfer itself. In addition, the effect of the performance of the transfer itself was considered by adding the performance of the transfer itself to the control variable block.

Adding the first block of control variables to performance after reaching steady state model (column 2 in Table 9) results in a significant regression model ($p < .01$) with an R^2 value of 0.13. The sender's experience and performance of the transfer itself (i.e. eventfulness) variables are significant at the $p < .01$ level, while the receiver's experience is significant at the $p < .08$ level. In accordance with the expectations, the greater the sender's experience of previous transfers and the lower the eventfulness during the transfer, the higher the performance is after steady state is reached. The negative effect of the receiver's experience, measured as moving to a brownfield site, means that we can expect greater long-term effects of moving to a greenfield (newly established) site compared to moving to a brownfield (existing) site. The knowledge property dimensions, added as Block 2, collectively explain a significant (at the $p < .08$ level) additional proportion of the variance in the performance of the transferred activity after reaching steady state, above that, explained by the first block of variables ($R^2 = 0.19$), resulting in a significant model ($p < .01$). The codifiability ($p < .01$) and independency variables were statistically significant in this model (in addition to sender's and receiver's experiences and the

Table 9. Regression for the performance after the transferred activity reaches steady state.

Independent variables	Dependent variable: Performance after reaching steady state Model 1	Model 2
Step 1: Control variables		
Company size	0.01	0.00
Sender's experience	0.27***	0.21**
Receiver's experience	−0.15*	−0.17*
Performance of transfer itself (Eventfulness)	−0.22***	−0.22***
Step 2: Knowledge property variables	–	0.20**
Codifiability	–	0.17**
Independency	–	0.01
Knowledge requirement	–	−0.02
Complexity	–	–
R^2	0.13	0.19
Changes of R^2	–	0.06
F-value of change of R^2	4.54***	2.10*
F-value	4.54***	3.41***

Note: $^{*}p < .08$; $^{**}p < .05$; $^{***}p < .01$.

performance of the transfer itself). *This verifies H2a and H2b for performance after steady state has been reached, but rejects H2c and H2d.*

5. Discussion

5.1 The impact of knowledge properties on transfer performance

This study provides further insight into how efforts should be distributed throughout the transfer process by studying how knowledge properties and unit properties impact transfer performance during the two phases of a manufacturing transfer. This is relevant when resources are scarce and not all aspects of manufacturing transfer can be given the same focus (Preast Knudsen and Madsen 2014). Our findings indicate that the properties of the knowledge of the transferred activity significantly affects both the performance of the transfer itself (i.e. the eventfulness) (R^2 increases from 0.06 to 0.15. $p<.05$) and performance after steady state has been reached (R^2 increases from 0.13 to 0.19, $p<.08$) when controlling for the properties of the units between which the activity is transferred. Therefore, we should expect the transfer performance to vary when transferring activities with different knowledge properties, regardless of the properties of the involved units.

Within the control variables, properties of the units (i.e. sender's experience, sender size and receiver's experience), we can see that the sender's size has no significant effect on performance in this study. The effect of size has varied in earlier studies (Van Wijk, Jansen, and Lyles 2008), and the lack of impact of size is therefore not a surprise. It is interesting to note that the sender's experience is only significant after steady state has been reached. This result implies that the senders are able to organise the transfer improves by learning (e.g. Szulanski 1996), but senders' experiences only improve performance after steady state has been reached and not the performance of the actual carrying out of the physical transfer and start-up. The last issue contradicts the results of Galbraith (1990). One explanation may be that each manufacturing transfer is unique and that not all possible events during the actual transfer and start-up can be foreseen by the sender. However, as the transfer reaches steady state, the sender has learned about the specific transfer and can compare this learning with earlier experiences. The experiences can thereby help to improve performance after steady state is reached. The fact that the receiver's experience, i.e. in this case whether it is a brownfield or greenfield site, impacts differently between the phases of the manufacturing transfer is also highly interesting. Transferring to a brownfield site reduces the eventfulness but also the performance after reaching of steady state, compared to transfer to a greenfield site. The fact that transfer to an existing brownfield site results in less eventfulness confirms suggestions by e.g. Cheng, Madsen, and Liangsiri (2010). However, the fact that transfer to a brownfield site results in lower performance after reaching of steady state than transfer to a greenfield site may seem contradictory. We can see two explanations for this result. First of all, Szulanski (2000) highlights the importance of recipients being able to discard old practices to integrate new ones, which can be a substantial challenge. In a brownfield site there are plenty of old practices that may have to be replaced, which may inhibit the integration of the new knowledge, and hence explain negative performance impact. A second explanation can be found in the sample, where a large proportion of the brownfield sites are owned by independent suppliers (43 out of 114), whereas the greenfield sites to a greater extent are subsidiaries or joint ventures (48 of 51). The performance of the greenfield site may, therefore, be improved because the sender is inclined to devote more effort to improving performance with an internal receiver than with an external supplier. To summarise, the use of both types of performance measures allow us to suggest that the impacts of the properties of the transferring units in the knowledge management context can vary between the phases of the manufacturing transfer, which should be considered in the preparations. Further research is needed, however, to fully explain the differing impact on transfer performance between the phases of a manufacturing transfer of receivers and senders experience, especially in relation to the effect of different types of relationships between sender and receiver.

5.2 The impact of individual knowledge property dimensions on transfer performance

Our findings show that different knowledge property dimensions are significant for the two performance measures. Independency is the only knowledge property dimension with a significant effect on both performance measures. This is an interesting finding, as the impact of independency on transfer performance has not been as extensively examined as have the complexity and codifiability dimensions. However, case-based studies have identified dependency as having a negative impact on manufacturing transfer performance (e.g. Kohlbacher and Krähe 2007), but Zander and Kogut (1995) was the only identified survey study (see Table 1) empirically testing the impact of independency.

Their focus was on the knowledge transfer speed between organisations, however not in conjunction with a manufacturing transfer, and they found independency to be insignificant. The fact that independency has a significant effect in this study could be traced to the fact that low independency implies an increased need to cooperate between more areas of the sending and receiving units. This may lead to a more complicated relationship, which can result in unexpected challenges during start-up and have a negative effect on performance after reaching steady state. These are highlighted as challenges related to the relocation of manufacturing activities in case studies for example by Vejrum Waehrens, Slepniov, and Johansen (2015) and Aaboen and Fredriksson (2016). However, as this is one of the first studies to include independency, further studies are needed to better understand the impact of independency on manufacturing transfers.

In our study, complexity was insignificant. The lack of impact of complexity on eventfulness is intriguing, as both Galbraith (1990) and Salomon and Martin (2008) have seen significant impacts of complexity on performance of the transfer itself. However, these studies have not used eventfulness as a performance measure, which may explain the lack of impact in our study. Regarding the lack of impact of complexity on performance after reaching of steady state, we confirm the results of Zander and Kogut (1995). The lack of impact of complexity is also in line with the results of Kinkel and Maloca (2009). They saw that complexity did not prevent companies from considering a product for offshoring. One explanation for the lack of impact of complexity may be that companies have mechanisms to deal with complexity during preparations of the transfer. There is a preparedness within the sending organisation that complexity may be an issue, and efforts are therefore directed at dealing with complexity. There are several previous studies showing how to handle complexity in manufacturing transfers (e.g. Malm, Fredriksson, and Johansen 2016; Cheng, Madsen, and Liangsiri 2010 and Grant and Gregory 1997a).

The codifiability dimension is significant in performance after reaching of steady state model, but not in the eventfulness model. The relatively low importance of codifiability during transfer itself is surprising, as codifiability has been considered a very important knowledge property dimension in previous studies (see Table 1) (Dhanaraj et al. 2004; Zander and Kogut 1995). What we see in this study is that codifiability improves the integration of knowledge within the receiver's manufacturing organisation as it improves performance after reach of steady state. The lack of significant impact on eventfulness can be explained in relation to the earlier discussion in more case-based research on the complex correlation between tacit and explicit knowledge and that supporting knowledge in the form of problem solving and fault finding skills are tacit and cannot be codified (Grant and Gregory 1997b; Cheng, Madsen, and Liangsiri 2010; Preast Knudsen and Madsen 2014). Therefore, even though the knowledge of the transferred activity is codifiable, the support knowledge is not necessarily so, and the support knowledge is only transferred by handling the quality and volume problems during start-up. Therefore, the codified knowledge related to the activity can be more readily retained and renewed as steady state is reached. These findings call for further studies to understand the relationship between tacit and explicit knowledge during the transfer itself.

The knowledge requirement was not significant in any of the models. Its lack of significant impact on either of the performance measures means that we cannot confirm the case-based findings of earlier outsourcing literature (Fredriksson and Jonsson 2009; Handfield and McCormack 2005). This indicates that the fear of many firms in identifying suitable receivers because of knowledge requirements may no longer be as critical as it has previously been. Several studies indicating significant performance effects of the knowledge requirement are old. Our findings indicate that the general manufacturing transfer/offshoring maturities of both sender and receiver units may have increased as manufacturing companies are now more international and have more experience of manufacturing transfers. Our sample of Northern European companies, of whom 60% have an overall strategy guiding manufacturing transfers, and 70% transfer activities to a subsidiary of their own or a joint venture in established manufacturing regions, i.e. Western Europe (13%), Eastern Europe (43%), and China (28%), indicates this.

6. Conclusions and future research

It is hard to successfully relocate manufacturing (Preast Knudsen and Madsen 2014; Fredriksson et al. 2015), which is shown in the growing research area of backshoring (Kinkel 2012; Stentoft et al. 2016). This paper studies the relationship between knowledge properties and two types of transfer performance, i.e. the transfer itself and during steady state. This is one of the first survey studies to have this focus, covering all phases of a manufacturing transfer. Thus, we fill a gap left by earlier studies that have focused on either the transfer itself or steady state. By using eventfulness as a measure we contribute by measuring the performance of manufacturing transfers in a new way. Furthermore, we also help to respond to the need identified by Pawar and Rogers (2014) for a better understanding of the performance of knowledge transfers, as this study allows us to increase the understanding of how the impact of knowledge dimensions differs between the transfer itself and after steady state has been reached. This study, thereby, contributes to the understanding and discussion of what activities, i.e. type of knowledge, should be considered for relocation. We conclude that knowledge properties as a group significantly affect both performance measures when controlling for the effects of sender unit experience, sender unit size and receiver unit experience. Thus, the activities transferred impact the success of the transfer.

Regarding the individual knowledge property dimensions, we find that their impact differs for the two types of performance. Independency is the only significant knowledge dimension for both types of performance. This study is one of the first to empirically test this relationship. We only see an impact of codifiability on performance after steady state has been reached, and not on the transfer performance itself. Further, we cannot see any significant effect of complexity and knowledge requirements.

This study has emphasised manufacturing activity transfer, though not the transfer of any specific product or production process, in any specify geographical receiver region, or involving any specific sender, receiver, or sender–receiver relationship. The fact that the study object is quite general could be considered a limitation. However, by adopting such a wide scope we were able to demonstrate that knowledge properties affect transfer performance independently of to whom and how the activity is transferred. The fact that the studied sending companies are located in Northern Europe (being a high-cost manufacturing region) and that most of them transfer their activities to existing subsidiaries in low-cost regions is also a limitation, as analysing data from regions with different transfer characteristics may alter the results. Furthermore, the study has covered both internal and external manufacturing transfers (to brownfield as well as greenfield sites) as these have been seen to be equally complicated in earlier case studies of manufacturing transfers (Aaboen and Fredriksson 2016). However, other studies of knowledge transfers (i.e. not in conjunction with a manufacturing transfer) have shown that there is a difference in performance impact of knowledge between internal and external knowledge transfers (Van Wijk, Jansen, and Lyles 2008). Thus, further studies of manufacturing transfers and knowledge properties should distinguish between internal and external transfers in order to identify whether the performance impact of knowledge properties differs between offshoring and outsourcing.

The survey instrument also has limitations, which for example was identified in the convergent validity tests. Several items are new and have consequently not been tested in previous studies. As the study is broad in scope, we had to compromise on the number of items in each scale. Moreover, the single items used to measure the receiver's experience and independency are also limitations. We believe our single-item measures are sufficient as they measure clear single issues. However, broader definitions and more sophisticated measures could be used in future studies. The absorptive capacity construct could, for example, be used instead of the brownfield/greenfield site to measure the receiver's experience. The same issue is relevant to the single item measure of independency, where we see a need for further studies to widen the scope of the variable to better understand the impact of independency on transfer performance. The dependent and independent variables are measured using perception-based measures, and all data are collected from the same respondents, creating a common method bias risk. However, the aim of the measure of the performance of the transfer itself (i.e. eventfulness) was to capture the transfer smoothness from the sender's perspective. To do this, one must ask the senders about their experience. Furthermore, regarding the performance after reaching steady state, we must recall that the respondents belong to the management team of the sender. These respondents should be able to provide good estimates of the profitability and productivity impact of the transfers, as 70% (See Table 2) of the studied transfers were to receivers under the control of the senders' management teams.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributor

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Appendix A. Measurement items of likert-scaled constructs.

Company size sender: Number of fulltime employees globally at company level (Natural logarithm).

Sender’s experience (Seven-point Likert scale, 1: Do not at all agree, 7: Largely agree):

- SEXP1: The company uses earlier experiences of manufacturing transfers when conducting new manufacturing transfers.
- SEXP2: The company has documented earlier experiences of manufacturing transfers in procedures, manuals or blueprints.
- SEXP3: The documentation of earlier experience has led to increased formalisation of communication and knowledge exchange.

Receiver’s experience: Is the activity implemented in a greenfield (new start-up) or a brownfield (existing) site? (1): Greenfield site, (2): Brownfield site.

Codifiability (Seven-point Likert scale, 1: Do not at all agree, 7: Largely agree):

- COD1: The activity is defined through goals and sub-goals.
- COD2: The activity is defined through procedures, manuals, blueprints, etc.

Independency (Seven-point Likert scale, 1: Do not at all agree, 7: Largely agree):

- INDEP1: The activity can be performed independently of the rest of the activities of the company.

Knowledge requirement (Seven-point Likert scale, 1: Do not at all agree, 7: Largely agree):

- KNOW1: The activity can only be performed by personnel with knowledge of and experience of similar activities.
- KNOW2: The activity can only be performed by personnel with university degrees.
- KNOW3: The activity can only be performed by personnel that have been trained for at least three months.

Complexity (Seven-point Likert scale, 1: Do not at all agree, 7: Largely agree):

- COMP1: The activity has many sub processes.
- COMP2: The activity is creative and innovative.

Eventfulness: Has the transfer of the activity resulted in any unexpected challenges within (Seven-point Likert scale, 1: Not at all, 7: To a large extent):

- EVENT1: Supervision of the activity?
- EVENT2: Coordination of the activity?
- EVENT3: Transfer of knowledge?
- EVENT4: Formalization and specification of the activity?

Performance after reaching steady state (Seven-point Likert scale, 1: Significantly decreased; 4: Unchanged, 7: Significantly increased):

- PERF1: How has the general effect of the manufacturing transfer been on productivity?
- PERF2: How has the general effect of the manufacturing transfer been on profitability?