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THE COMPLEMENTARITY OF KNOWLEDGE STOCKS AND FLOWS WITHIN AND ACROSS VALUE-CHAIN FUNCTIONS

ABSTRACT

While previous research has focused on either the investigation of knowledge assets (stocks) or knowledge flows, our study is among the first to integrate both these important elements of the knowledge-based theory of the firm. We study the extent to which knowledge stocks and flows are complementary within and across value-chain functions. Based on a comprehensive sample of 324 knowledge flows occurring within 162 MNC units we find that these units profit strongly from knowledge inflows when they possess respective knowledge stocks in the same function. Complementarity effects also occur when downstream knowledge is transferred backwards to upstream functions, but not vice versa. We discuss our research in the light of the knowledge-based theory of the firm.

INTRODUCTION

Historically the focus in literature on the multinational corporations (MNCs) has been on ownership specific factors and the possession of *stocks* of assets. As highlighted by Dunning (1988) the main condition for becoming a MNC in the first place is that firms possess stocks of assets. The resource-based view of the firm also put the main emphasis on knowledge stocks qua their strong attention on existing resources as the main source of competitive advantage (e.g. Dierickx and Cool (1989) who emphasises how knowledge stocks may provide competitive advantage for firms).

In contrast to this early literature on the knowledge stocks, a very large part of the recent knowledge-based MNC literature focuses on knowledge sharing among MNC-units (i.e. is *flows* of knowledge) as it is generally accepted that MNCs gain competitive advantage by combining the heterogeneous knowledge in their different MNC-units (Kogut and Zander, 1992; 1993). During the last years, the majority of studies has focused on the question how factors impeding knowledge flows can be alleviated and how knowledge flows can help to create value in the MNC (e.g. Szulanski, 1996; Simonin, 1999; Gupta and Govindarajan, 2000; Tsai, 2001; Minbaeva et al., 2003). It is often (implicitly) assumed that value creation is a mere function of how much knowledge the unit receives. This literature typically takes a flow-based view where little attention is devoted to how knowledge flows among subsidiaries are connected to the stocks of knowledge in the individual subsidiaries.

Accordingly, investigations of knowledge management within the MNC have largely focused on either the analysis of knowledge assets (i.e. stocks) or knowledge sharing (i.e. flows) and have mostly separated these dimensions theoretically as well as empirically. The literature has

mainly taken a stock-based view or a flow-based view and rarely discussed the combination of knowledge stocks and flows (Doz et al., 2008; Foss and Pedersen, 2004).

We are arguing that value is created exactly in the interface between stocks of knowledge and flows of knowledge. Flows of knowledge might be of little value unless they can be combined with the existing stocks of knowledge. In fact, the benefits of knowledge sharing must emerge out of the complementarity between stocks and flows of knowledge. Some important implications of the lack of theoretical understanding on how knowledge stocks and flows are related are twofold. First, we have limited understanding of benefits of knowledge flows e.g. are knowledge flows always beneficial or can they also be harmful for value creation? Second, there is a lack of research investigating to what extent different types of knowledge stocks and flows are complementary and value creating.

In this paper, we seek to address these limitations and shed some light on the complementarity of knowledge stocks and flows in MNC units. We focus on the interaction of knowledge stocks and flows across different MNC units, and investigate different combinations, i.e. within and across value chain functions. The main logic of our study (and the formulated hypotheses) rests on the simple argument that value creation from knowledge exchange within MNC units should be highest when *complementary* knowledge stocks and flows are combined.

The empirical test of our hypotheses is conducted on a sample of 324 knowledge relationships between organizational units in 48 European multinational corporations. For these cases of knowledge relationships information is available both on stocks and flows of knowledge for upstream knowledge (i.e. technological and purchasing knowledge) and downstream knowledge (i.e. marketing and distribution knowledge).

The contribution of this research lies in showing that value creation from knowledge is a function of the interaction of stocks and flows. Knowledge inflows alone do only produce limited value when they are not combined with proper stocks of knowledge. Further, our analysis across upstream and downstream functions reveals that complementarity does exist across functions. Upstream activities with a certain level of upstream knowledge stocks profit from combining their stocks with incoming flows of downstream knowledge. However, downstream activities do not seem to benefit from incoming flows of upstream knowledge. We discuss our findings in light of the interdependencies within the MNC value-chain. We add to the broader literature on the knowledge-based theory of the MNC (Hedlund 1994; Kogut and Zander, 1992, 1993, 1995; Grant 1996, Easterby-Smith and Lyles, 2003) since our findings connect individual elements of this perspective with each other. We also discuss implications for the literature on absorptive capacity.

LITERATURE BACKGROUND

Value Creation from Knowledge Stocks and Flows

Knowledge *stocks* are accumulated knowledge assets, which are internal to the firm and *flows* are knowledge streams. Large part of the literature on MNCs put emphasis on the stocks of knowledge. Thus, in his OLI-framework, Dunning (1988) emphasizes stocks by acknowledging the importance of ownership specific advantages (e.g. like patents, superior technology, brands). The possession of ownership specific advantages is a main condition for making foreign direct investments in the first place. Without ownership specific advantages (stocks of assets) the firms will not have any potential to overcome the liability of foreignness abroad and to internationalize their activities.

Building on the resource-based view of the firm, Dierickx and Cool (1989) develop the theoretical argument that knowledge stocks can be a source of competitive advantage, as they are generally not tradable and difficult to imitate by competitors. Knowledge stocks may thus be seen as building blocks of (dynamic) capabilities (Grant, 1996; Eisenhardt and Martin, 2000; Zollo and Winter, 2002) or core competences (Prahalad and Hamel, 1990) of the firm. This perspective suggests that knowledge stocks provide economic value through their mere existence. In addition to the often cited VRIN resource characteristics (see e.g. Barney 1991), several other factors are likely to determine the economic value of a particular knowledge stock. We propose that, in the MNC context, they can be categorized in factors pertaining to the location of the knowledge in the organizational network, such as the unit's location (e.g. Porter, 1980; Kuemmerle, 1999), its mandate (e.g. Birkinshaw and Morrison, 1995), or its activity structure (e.g. Andersson, Mudambi and Persson, 2006) as well as knowledge-specific characteristics such as tacitness, observability, teachability (Kogut and Zander, 1992; Birkinshaw et al., 2001).

However, recently scholars have stressed that exploiting dispersed knowledge stocks to its fullest extent necessitates more than simply possessing and utilizing these stocks in individual units (Martin and Salomon, 2003; Hansen and Lovas, 2004). Valuable knowledge is also created in the MNC-subsidiaries e.g. through their intense business-relationships with local counterparts or through the acquisition of knowledge of a university laboratory. Dispersed organizational units within the MNC are developing specific activity profiles due to headquarter assignments, self-induced developments, and local environmental determinism (Birkinshaw and Hood 1998). Hence, subsidiary activities are often connected to specific local collaborations with suppliers, customers, and universities which are the basis for unique knowledge elements to be developed.

The competitive advantage of the MNC lies particularly in leveraging the knowledge stock in the global network of subsidiaries (e.g. Barlett and Ghoshal 1989; Gupta and Govindarajan 1991, 2000). This implies the transfer of knowledge from one unit to another within the MNC where this knowledge might be of value. In other words, value creation is only maximized when the MNC engages in intra-MNC knowledge flows. Hence, in addition to knowledge stocks, knowledge flows are a potential source of value. In fact, the ability to leverage its knowledge resources globally has been proclaimed by many scholars as the true raison d'être of the MNC (Kogut and Zander, 1992; 1993; Doz et al., 2001; Mahnke and Pedersen, 2004; Monteiro et al., 2008).

A common approach in this literature has been to conceptualize and operationalize the knowledge stock in accordance with the *'bathtub' metaphor* (Cohen & Levinthal, 1989; 1990; Doraszelski, 2003). This metaphor suggests that MNC units can be seen as possessing proprietary *stocks* of knowledge (like water in a bathtub) that may be affected by *flows* such as those caused by R&D, inter-firm spillovers, or knowledge 'depreciation', to name a just few. The implication is that MNCs and their subunits may accumulate knowledge, as long as their inflows are larger than their outflows, and thereby increase the size and value of their knowledge stocks. This view of knowledge as described above is clearly a simplification, but it has been a powerful one on which a vast body of important and influential research has been built. However, we will claim that knowledge stocks and flows – unlike water in a bathtub – consist of multiple dimensions that may be complementary or not. Therefore, when MNC-units acquire new knowledge (through inflow of knowledge) the flow of knowledge might be complementary to the existing stock of knowledge (and add water to the bathtub) or it might not be (and don't add any new water).

Despite a number of empirical investigations on value creation from knowledge transfer (e.g. Monteiro et al., 2008; Ambos et al., 2006; Szulanski and Jensen, 2006; Mahnke et al., 2004; Haas and Hansen, 2005) extant research does not seem to provide a stringent theoretical explanation under which circumstances organizational units benefit from knowledge transfer. While the above-mentioned studies suggest that not every transfer is beneficial per se and that its relevance or application in a new context will depend on contextual contingencies, the potential of "knowledge combination" has remained in the dark and still rests on the relatively vague idea of a "positive theory of the firm" (Kogut and Zander, 1993; Ghoshal and Moran, 1996; Nickerson and Zenger, 2004). One generally accepted finding though, is that, knowledge varies in the degree to which it can be transferred from one unit to another and paradoxically, the same characteristics that increase the economic value of knowledge, such as tacitness or inimitability, also render it notoriously difficult to transfer – and thus to exploit – not only across but also *within* the firm.

The costs of knowledge transfer are well documented in the literature and stemming from a range of factors such as the characteristics of the knowledge itself, of the sender, and of the receiver (Teece, 1977; Kogut and Zander, 1993). Knowledge transfer will therefore only be attractive if the (expected) benefits outweigh the costs. However, these benefits of knowledge flows are often just taken for granted, and rarely documented in empirical studies. The underlying assumption in most studies is that if knowledge flows are taken place it must be beneficial as they would not take place otherwise given the substantial costs of knowledge transfer even within the boundaries of the MNC.

The Complementarity of Knowledge Stocks and Flows

Generally, there are benefits to knowledge transfer if (and only if) the inflows of knowledge and existing stocks of knowledge are complementary. Flows and stocks of knowledge are

complementary if the marginal return of flows increases in the level of the stocks of knowledge (Milgrom and Roberts, 1995). In other words, if having larger stocks of knowledge, the marginal benefits of having more complementary flows of knowledge increases. For example, when a MNC-unit has high level of technical knowledge, the transfer of advanced user needs and wished for product improvements will be beneficial. In fact, the larger the existing stock of knowledge the more valuable the inflow of new knowledge as the prior knowledge make a larger pool of knowledge to draw on both in terms of new solutions and also in order to understand the depth of the transferred knowledge. The MNC-unit would on the other hand not be able to reap the benefits of the transferred knowledge if it had no prior knowledge stocks to draw on whatsoever. This little example illustrates very well the basic idea of complementarity among stocks and flows.

Buckley and Carter (2004) highlight that knowledge complementarity can be separated into three distinct types of complementarity, i.e. additive, sequential and complex forms of complementarity. The additive type of complementarity is when knowledge residing in different places is transferred to a common place and combined with existing knowledge. One example would be if some technical knowledge is transferred to a location where it is combined with the existing marketing knowledge. Both the sequential and complex types of complementarity refer to cases with higher levels of interaction between the sender and receiver of knowledge. Seminal studies (Nelson and Winter, 1982; Kogut and Zander, 1992) posit that value creation depends on the firm's "combinative capability" which is the ability to combine and re-combine the stocks and flows of knowledge across existing boundaries in the firm. Finding optimal combinations of complementary knowledge is therefore a key task for a firm which poses, however, tremendous difficulties, especially in the context of the MNC.

In addition, we know very little about the character and conditions of this knowledge combination – the interaction between the stocks and flows of knowledge – other than on a relatively abstract level. E.g. what kind of knowledge stocks and knowledge flows are really creating value in their interaction? Is it all kinds of stocks and flows or only particular combinations of stocks and flows that create value in their interaction? While research on the benefits of combining knowledge stocks and flows is rare, there is, by consequence, also a lack of research investigating to what extent different types of knowledge stocks and flows can be combined. Although the concept of absorptive capacity is in the center of many studies' investigations (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998, Zahra and George, 2002, Lane et al., 2006), our understanding on how incoming knowledge is linked to existing knowledge stock is scarce. And mostly, the ability to create value from knowledge is contingent on prior knowledge in the same functional area. Yet the firm's ability to create new knowledge from existing stocks and flows also depends on combining different knowledge elements, e.g. from marketing and R&D.

In this paper, we investigate the complementarity of knowledge stocks and flows as our study focuses on the *combination of dispersed knowledge within and across value chain functions*. We view the organizational units as nodes, which possess and receive specialized knowledge. As knowledge relationships in multinational corporations are extremely complex due the multiple linkages organizational units possess, we restrict our focus to dyadic relationships, i.e. knowledge relationships between two different units, which may include headquarters as well as subsidiary organizations. We distinguish knowledge stocks and flows within downstream and upstream activities. Downstream knowledge stocks, in our definition, include know-how in the area of marketing and distribution. Upstream knowledge stocks include purchasing and technology know-how. The term know-how is used in accordance with previous research which defines know-how as knowledge which allows the organizational

unit “to do something smoothly and efficiently” (Kogut and Zander, 1992, p. 386). This approach clearly distinguishes our research from others, who refer to patents or R&D spending to represent knowledge assets (De Carolis and Deeds, 1999; Cohen and Levinthal, 1990; Penner-Hahn and Shaver, 2005),

HYPOTHESES DEVELOPMENT

Combining Knowledge Stocks and Flows Within and Across Functions

The relation and interaction between knowledge stocks and flows has been treated ambiguously in prior research. One of the most important lines of thought that systematically connects knowledge stocks with incoming flows is the concept of “absorptive capacity”. In their seminal paper, Cohen and Levinthal (1990) explicitly build their definition on the “ability to recognize the value, assimilate, and apply” incoming (transferred) knowledge with the unit’s existing stock of knowledge. They suggest that organizations – or organizational subunits – will only be able to benefit from incoming knowledge if they possess a stock of knowledge in the respective field that allows them to connect the different knowledge elements. Although Cohen and Levinthal do not discuss the micro-processes of knowledge combination and propose a rather crude empirical measure (R&D spendings), the concept of absorptive capacity has been in the center of the academic debate during the last two decades (for reviews see Zahra and George, 2002; Lane et al., 2006).

In this stream of thinking, scholars argued that a unit’s response to knowledge inflows is influenced by its interpretations and perceptions, which are primarily shaped by its existing knowledge stocks (van den Bosch et al., 1999; Tsai, 2001; Lane et al., 2001). Most important for the understanding of absorptive capacity in dyadic knowledge relationships is probably the work of Lane and Lubatkin (1998) who conceptualize a student-teacher relationship, which impacts the recipient’s ability to absorb knowledge. We adopt this perspective in our research

as we include intra-organizational dyadic knowledge relationships and evaluate a unit's knowledge stock relative to its peers. Even if MNC units differ in their amount of knowledge and expert status, the absorptive capacity argument suggests that an *overlap* between knowledge elements possessed by the sending and the receiving unit is a prerequisite for value creation. Yet, Cohen and Levinthal (1990) – as well as others – are quite unspecific when it comes to the amount of overlap necessary. They state that prior knowledge stocks create absorptive capacity when "some portion of that prior knowledge (is) closely related to the new knowledge to facilitate assimilation, and some fraction of that knowledge (is) fairly diverse, although still related, to permit effective, creative utilization of the new knowledge (1990: 136). It is unclear what "some fraction", "fairly diverse", and "still related" really means (Shenkar and Li, 1999), but the answer to this question is very important for understanding the process of value creation. Relatedness can be interpreted as a situation in which knowledge stocks and flows come from the same knowledge domain (Cohen and Levinthal 1990). For example, it is reasonable to assume that know-how pertaining to the same functional area, i.e. marketing, within one firm is relatively related. It is also appropriate to assume that the necessary level of diversity is given when two MNC units located in different countries transfer knowledge of the some domain. Due to their embeddedness in the national context (Andersson et al., 2002) their knowledge assets within, say, marketing, may not be entirely substitutable.

Hence, we hypothesize that a repository of knowledge stocks in a certain functional area facilitates value creation from knowledge inflows in the respective area as it provides the necessary absorptive capacity. We suggest that this is true for know-how on downstream as well as upstream activities and develop the two following hypotheses.

H1a: Under conditions of high knowledge stocks in upstream activities: the higher the knowledge inflow of upstream knowledge, the higher the value creation for upstream activities.

H1b: Under conditions of high knowledge stock in downstream activities: the higher the knowledge inflow of downstream knowledge, the higher the value creation for downstream activities.

Another stream of thinking builds on the idea of value chain activities and interlinkages of functions within the MNC (e.g. Porter, 1980; O'Donnell, 2000). As the network MNC is characterized by complex interdependencies and a distribution of activities across several subunits, it is of utmost importance for the operation and the raison-d'être of the MNC that knowledge across different functional areas, e.g. marketing and R&D, is combined (more efficiently than through market mechanisms) (Kogut & Zander, 1992; Ghoshal & Moran, 1996). The challenge of knowledge combination of existing knowledge stocks with incoming flows is likely to be highest when substantially different knowledge, from different functional areas, is involved (Ambos and Ambos, 2009; Haas and Hansen, 2005). But also the value creation potential from knowledge combination is likely to be higher – although more riskier. As Buckley and Carter (2004:374) put it: "The gain to the firm from combining knowledge comes from the effect on activity choices and hence on the outcome for the firm."

For example, R&D units might profit substantially from new incoming knowledge regarding customer preferences and behavior as this helps adjusting R&D efforts. Gupta and Govindarajan (2000) conjecture that "complementary" knowledge transfers between units "along different stages in the company's value chain" (491-492) are more likely to succeed than transfers in so called "substitutive" relationships, i.e. a situation where sender and recipient are experts in the same functional area. Building on this argument, Andersson et al.

(2006) found that subunits that are undertaking different activities are relatively more effective in transferring knowledge than two subunits undertaking similar activities. They also argue that such complementarity makes it easier to motivate the sending unit to engage in the transfer and to motivate the receiving unit to search for such valuable knowledge in the first place as the relationships are non-competitive (Andersson et al., 2006).

Building on the above, we hypothesize that firms create value by combining knowledge stocks and flows *across* functional areas, i.e. upstream and downstream activities.

H2a: Under conditions of high knowledge stock in downstream activities: The higher the knowledge inflow of upstream knowledge, the higher the value creation for downstream activities.

H2b: Under conditions of high knowledge stock in upstream activities: The higher the knowledge inflow of downstream knowledge, the higher the value creation for upstream activities.

METHODOLOGY

Sample Design

The European Top 500 served as a sample frame for this study. The research plan involved data collection at two levels, headquarters and subsidiaries. To ensure variety, both in terms of subsidiaries and industries involved, we restricted our sampling efforts to those firms known to operate at least six overseas subsidiaries (Vernon, 1966), whilst on the same hand using direct proportional strata on ten industries to ensure industry variety. An initial target sample of 60 MNCs was set. Data collection started in May 2002. Firms within each stratum were contacted in descending order. Whenever a company declined to co-operate in the survey, the next largest company in terms of turnover was approached. Starting with the largest

corporations, senior managers from each headquarters were contacted and asked to co-operate. Upon agreement, each was asked to nominate four subsidiaries, which could participate in the study. This sampling procedure led to a final target sample of 300 units, i.e. 60 headquarters and a total of 240 subsidiaries. A standardized mail survey was sent out to all participants. Two follow up rounds and the promise to provide results aimed to ensure a high response. Despite these efforts, and the initial agreement of headquarters, it was impossible to collect responses of all the firms in time. The final sample consisted of 162 MNC units belonging to 48 companies. Thereof 38 headquarters and 124 subsidiaries participated and reported on multiple knowledge transfer relationships within their organization. Each headquarters reported on its knowledge transfer practices with two subsidiaries, and each subsidiary on their interactions with headquarters and a peer subsidiary. This led to a total of 324 transfer relationships.

The sample composition shows significant variance. The final sample represents leading MNCs of diverse industries, such as manufacturing (56%), finance and insurance (21%), and other services including consulting companies (11%). Surveyed units operate in 29 countries. The smallest distance between units is 0, i.e. a case where headquarters and subsidiaries located in the same city. The average headquarters employs 1,019 employees whereas the average number of subsidiary personnel is 638. Although 8.5% of the units have more than 2,500 employees 50% of the sample have a relatively small unit size, i.e. less than 250 employees. Nearly half of the subsidiaries (44%) have been formed as a Greenfield investment, the remaining originated from a merger or acquisition.

The unit of analysis in this study was a *dyadic knowledge relationship* between two organizational units, e.g. headquarters and one subsidiary or two subsidiaries. To assess non-response bias we tested whether responding firms differed from non-responding firms with

respect to size and turnover. Both tests showed non-significant differences between responding and non-responding firms.

Model Estimation

Our econometric approach is a simultaneous equation estimation using a three-stage least squares method (Green, 1997; Nickerson et al. 2001). Hence, we use instrumental variables to produce consistent estimates and generalized least squares to account for correlation in the disturbances across equations. Stage 1 of our procedure can be interpreted as producing instrumented values of our two endogenous variables which are in our case the level of knowledge stocks and flows. The second stage produces a consistent estimate of the effect of the two endogenous variables on our final dependent variable value-creation. By doing so, we avoid the risk of endogeneity problems. This is warranted since one important source of endogeneity problems are measurement errors which are likely given the abstract nature many aspects of knowledge elements and the resulting imperfections in terms of its measurement.

While in general some prior research exists on the determinants of stocks and flows, most studies have investigated these concepts separately. Dierickx and Cool (1989) also point to the difficulty of clearly identifying the drivers of such a knowledge accumulation process. “Firms with more knowledge can engage in superior trading opportunities with greater confidence in the viability of their plans, in their ability to carry them out, and in the value they will achieve in the prevailing conditions.” (Buckley and Carter, 2004). Research is especially scarce which predicts knowledge stocks.

We are using the following determinants originating within the firm or from the external environment in which the units are operating. One important factor mentioned in the literature is how units store and govern knowledge in a way so that it is accessible and up-to-date. To

this end, organizational processes, that is, clear rules for formatting and categorizing knowledge are mentioned as a determinant of knowledge stocks (e.g. Buckley and Carter, 2004). Scholar focusing rather on the formal organizational structure have emphasized that a clear hierarchical organization of the firm eases the units' job to manage and maintain their knowledge stock (e.g. Birkinshaw et al., 2001; Almeida et al., 2002). Finally, larger units can be expected to dispose of more important knowledge stocks. With regard to the external environment, a number of scholars have reported that the extent to which an local environment challenges to the survival of firms, the more such firms are required to develop capabilities and know-how to cope with this environment (Porter 1980; Asmussen et al. 2009). Along the lines of this literature, we integrate the sophistication of local market competition as a predictor of knowledge stocks.

There is more information in the literature on the antecedents of knowledge flows. The literature highlights on the one hand processes such as personal coordination mechanisms to facilitate knowledge flows. On the other hand, the technical infrastructure has been found to be an important antecedent as well. Finally, the extent to which business practices between the sending and the receiving units are similar reduces knowledge sharing obstacles and costs (Becerra-Fernandez and Sabherwal, 2001; Hansen and Lovas, 2004). For both knowledge stocks and knowledge flows we are also controlling for the type of unit being either a subsidiary or the headquarters.

Measurements

The data used in this study came primarily from a questionnaire. As headquarters' and subsidiaries' managers were addressed, two slightly different versions of the questionnaire were created. The questionnaires were pre-tested in a series of cognitive interviews with researchers, and managers involved in the research topic. Several amendments, mainly in

wording, were conducted before the final instrument was sent to managers. Additional insights were gained through field interviews in different subsidiaries of nine multinational firms to cross-validate our empirical results. The following section briefly introduces the operationalization of our variables.

Dependent and Independent Variables

Value Creation. Two variables were created that capture the value creation since we distinguish between value creation for upstream and downstream activities. The value from knowledge transfer created for the recipient was measured with survey instruments that captured the perceived benefit to the downstream activities from knowledge sharing across two know-how domains: marketing know-how and distribution know-how. Value creation for upstream activities was based on technology know-how and purchasing know-how (1= not at all; 7= a very great deal) (see also Gupta and Govindarajan, 2000).

Knowledge Stocks. The recipient unit's knowledge stock relative to the senders' (i.e. headquarters or a subsidiary) in different knowledge domains was used as a measure. The knowledge domains mirror those used for the effectiveness measure. Cronbach alpha is 0.797.

Knowledge Inflow. The knowledge inflows of a focal unit were assessed based on the two times two different know-how categories as reported above. Our approach is similar to Gupta & Govindarajan's (2000).

Determinants of Knowledge Stocks

Knowledge Management. "Our company has clear rules for formatting and categorizing its…" (1) product knowledge, (2) process knowledge and answered on a seven-point scale ranging from "I strongly disagree" to "I strongly agree". (See also Becerra-Fernandez and Sabherwal, 2001)

Hierarchical Governance. "A clear hierarchy is very important for our organization" answered on a seven-point scale ranging from "I strongly disagree" to "I strongly agree".

Unit Size. Unit size was measured as the (logged) number of employees at the focal unit.

Country Competitiveness. The country's competitiveness of the focal unit was assessed using the World Competitiveness Index published by IMD. We created a dummy variable taking the value of 1 if the focal unit's country ranks higher on the competitiveness scale than the knowledge sender, and 0 otherwise.

Determinants of Knowledge Flows

Personal Coordination Mechanisms. The operationalization of this variable was adopted from Gupta and Govindarajan (2000). The use of coordination instruments in lateral and hierarchical relationships was explored separately. Respondents were asked to indicate how much they relied on liaison personnel, temporary task forces, and permanent teams as means of knowledge sharing in different directions. The scale ranges from 1 (very infrequently) to 7 (very frequently). Cronbach alpha is 0.756.

Technological Infrastructure. To assess the units' ability to use technical infrastructure for inter-unit knowledge transfer, a multiple item construct was created based on Becerra-Fernandez and Sabherwal (2001). The items refer to a number of different tools, which are used to access knowledge in other parts of the organization. These include tools to (1) collaborate with persons outside the unit, (2) multiple learning tools, (3) search facilities, (4) technology to retrieve information about products and processes as well as (5) markets and competition, and (6) to partner collaboration tools.

Similarity of Business Practices. To capture the degree of similarity between the partners' business practices we adopted the measure from Simonin (1999), which was answered on a seven-point scale ranging from "I strongly disagree" to "I strongly agree".

Controls

Formal Position. A dummy variable for headquarters (1) and subsidiaries (0) served as a proxi for the unit's formal position.

Direction of Knowledge Flow. To control for the direction of knowledge flow, we used dummy variables for forward (headquarters to subsidiary), reverse (subsidiary to headquarters) and lateral (subsidiary to subsidiary) knowledge flows.

Geographic Distance. We also controlled for the geographic distance between knowledge sender and recipient using the logged number of airmiles between the units.

Facilitating Knowledge Transfer Processes/Channels. Use of (vs. mere existence of) (1) databases, (2) web-based access to data, (3) repositories of best practices/lesson learnt, (4) webpages.

RESULTS

The results are presented in Table 1. Our system of equations converges quickly to stable estimates. Model fit is acceptable with significant F-Values ($p < .01$) and R Squared values ranging from 0.09 to 0.21 for all specifications. The first two results columns show the unstandardized coefficients of the predictors of upstream knowledge stocks and downstream knowledge stocks respectively. There is support for the idea that knowledge management rules and procedures explain the level of knowledge stocks. Unit size and country competitiveness do not have an effect on the level of stocks. Hierarchical governance is rather negatively related to knowledge stocks although support is weak. Finally, in case of the unit being a HQ, knowledge stock levels are lower for both upstream and downstream activities.

The columns three and four show the results for predicting the level of knowledge inflows (upstream and downstream inflows). The results show that all predictor variables are strongly significant and positive antecedents of knowledge inflows with the exception of technical infrastructure which does not seem to have an effect on upstream knowledge inflows. Hence,

consistently with previous findings, personal coordination mechanisms as well as similar practices between senders and receivers increase knowledge inflows. Contrary to stocks of knowledge, HQs seem to receive more knowledge than subunits.

The last two columns show the effect of the direct and combined effects of the instrumental variables of stocks and flows on value creation. Column five shows that neither upstream stocks nor upstream inflows or downstream inflows have a direct effect on value creation. Yet, both interaction terms representing hypothesis 1a and 2a feature positive and significant coefficients ($p < .001$). Hence, upstream knowledge stocks create value for upstream activities only in case they are combined with knowledge inflows – no matter if these are knowledge inflows in the same activity area (upstream) or if they are downstream inflows. However, the positive effect of H1a is roughly three times the effect of H2a. Of the control variables, only later transfer is significant, indicating that lateral knowledge transfer creates fewer benefits for upstream activities than hierarchical transfer

Column 6 repeats the analysis for the final dependent variable of value creation for downstream activities. Results are qualitatively similar to the model predicting upstream benefits. However, only H1b receives support while H2b is not supported. This means that downstream activities benefit neither from knowledge stocks or flows directly, but they benefit from a combination of downstream stocks and downstream inflows. However, upstream knowledge inflows do not seem to create value for downstream activities – neither alone nor jointly with downstream knowledge stocks.

DISCUSSION AND CONCLUSION

Our study is one of the few studies explicitly investigating the complementarity between different types of knowledge stocks and flows. We find that knowledge does indeed flow within MNCs but such transfers do not necessarily create value in all cases. In general, we find that inflowing knowledge has to meet respective knowledge stocks in the same function

or in activities in further upstream-oriented functions in order to produce benefits for the knowledge-receiving unit.

Our findings have several important implications for the theoretical discussion of the knowledge-based theory of the firm:

First, our findings show that MNCs are creating benefits mainly when knowledge stocks and flows are complementary, and this effect of within-function knowledge sharing and combination seems to be very important. The finding aligns with previous research arguing that knowledge sharing within functions is successful due to available absorptive capacity. However, previous research has also suggested that units operating within the same domain might perceive the other unit as competitors (substitutive relationship between sender and receiver e.g. Andersson et al. 2006) and hence refrain from knowledge transfer. Based on this assumption and our finding that within-function knowledge sharing has the strongest effect on knowledge sharing benefits, we suggest that firms need to invest particularly in remedies to motivational issues of units who perceive their relationship to other units as competitive. In more general terms, our research shows that a strong focus on either stocks or flows is falling short of important mechanisms that explain firm performance. Future research should thus refrain from a narrow focus.

Second, our findings suggest that the combination of knowledge stocks and flows produces benefits when the stocks and flows occur across different functions. The effect across functions, however, seems to be much less substantial than the effect of knowledge combinations within one particular function (that is when stocks and flows pertain to the same knowledge domain). The within-function interaction coefficient is roughly three times the coefficient of the cross-functional interaction coefficient. This combines nicely with previous

research proposing that non-substitutive relationships between knowledge senders and receivers facilitate the transfer of knowledge (Andersson et al. 2006). Hence, while the positive effect of within-function knowledge sharing is much stronger than across functions, it is at the same time more difficult to achieve. This adds another aspect to the paradox of the knowledge-based theory of the firm in which especially those knowledge elements are supposed to add to the sustainable competitive advantage that are difficult to identify and transfer within the firm. Another implication is that knowledge sharing systems might be or should ideally be relatively function-specific as the lion share of complementarity benefits occur within functions. Firms could be perceived as sets of function-specific knowledge sharing systems which allow for cross-functional transfer only on rare occasions. Future research could build on this idea and shed light on such differences between functions as well as potential specific scanning and supporting mechanisms to be used for knowledge complementarities across functions. Future research could also engage in a more detailed differentiation of value-chain functions which separate different activities and integrate also support functions such as IT or HR.

Third, our findings show that the value-chain sequence seems to be an important determinant of complementarity effects across functions. “Backward complementarity” can be found, i.e. downstream knowledge can be successfully transferred to upstream functions where it creates value in combination with the existing upstream knowledge stocks. However, we do not find “forward complementarities” in which upstream knowledge creates value when transferred to downstream functions where it meets extant downstream knowledge stocks. Hence, complementarity effects of knowledge sharing occur with opposite directionality than the “flow” of materials and end products within the value-chain concept. From the perspective of absorptive capacity, this result can be interpreted as a situation in which upstream knowledge stocks are more receptive to complementarities, i.e. provide a broader level of absorptive

capacity than downstream knowledge stocks which can only make use of downstream knowledge inflows. Furthermore, our findings are in stark contrast to previous literature which – in a somewhat coarse-grained and imprecise manner – often attributes complementarity simply to two different functions when they are located in different stages of the value chain (e.g. Gupta and Govindarajan, 2000). Cross-functional knowledge-sharing is thus much less important and only productive under certain circumstances. Equaling cross-functional sharing with important complementarity effects is therefore misleading and might create substantial costs of useless transfers when implemented within firms. Future research could shed more light into the directionality of complementarities and investigate also the extent to which firms are able to differentiate their costly knowledge transfer mechanisms.

Finally, our results suggest that firm do engage in "unproductive" knowledge transfer, that is, knowledge transfer that is not producing benefits at the receiving unit because of a lack of absorptive capacity or a misfit in terms of value-chain directionality. This complements previous literature which has focused on the tremendous difficulties that firms face when they try to achieve knowledge transfers (e.g. Szulanski 1996). Our results suggest that, ultimately, benefits of knowledge transfer and sharing are not necessarily given even if the units that engage in the sharing overcome the barriers to transfer in the first place. Hence, ambiguities and misinterpretation of complementarities might lead to substantial "useless" flows. The latter might be the result of un-specific promotion of knowledge transfers or the existence of standardized transfer-facilitating tools and mechanisms. This suggests that firms are in general much less successful with knowledge sharing than assumed and it shows the negative side of knowledge sharing mechanisms and tools as useless flows bring about high transfer costs. Furthermore, based on our findings we suggest modifying the interpretation of the positive theory of the firm. The dominant connotation of the positive theory is that successful firms have high combinative capabilities which means that they are able to combine

complementary knowledge elements within their organization. While we do not challenge the basic idea we suggest that firms might rather be conceived as trial-and-error knowledge systems instead of an organization which has a specific view on how to find performance "peaks" in their multitude of potential knowledge combinations. The "combinative capability" of the firm would thus refer as much to a firm capable of avoiding useless transfers which produce direct and opportunity costs, as it refers to a firm capable of finding the value-creating combinations of knowledge. This is a subtle but important distinction which could be further analyzed in future research.

Table 1: 3SLS model for value creation through knowledge stocks and flows

	Stocks of upstream knowledge	**Stocks of downstream knowledge**	**Inflows of upstream knowledge**	**Inflows of downstream knowledge**	**Upstream benefits**	**Downstream benefits**
Knowledge Management (RULES)	0.10*	0.22***				
Hierarchical Governance (ORG_3)	-0.05	-0.06*				
Unit Size (EMPL_UMS)	0.001	0.001				
Country Competitiveness (COMP_R)	0.04	-0.06				
Type of Unit (HQSUB)	-1.11***	-0.27*	1.06***	0.65***		
Personal Coordination Mechanisms (COORD)			0.23***	0.19**		
Technical Infrastructure (INFRA_FFS)			0.11	0.22**		
Similarity of Business Practices (DIPRAC)			0.14**	0.15**		
Upstream Stocks					-0.04	
Upstream Inflows					-0.10	-0.33
H1a: Upstream Stocks * Upstream Inflows					0.18***	
H2a: Upstream Stocks * Downstream Inflows					0.06***	
Downstream Stocks						0.21
Downstream Inflows					0.12	0.12
H1b: Downstream Stocks * Downstream Inflows						0.21***
H2b: Downstream Stocks * Upstream Inflows						0.02
Control variables:						
Lateral Transfer (D_LAT)					-0.70**	-0.70**
Forward Transfer (D_FWD)					-0.60	-0.60
Geographic Distance (LNAIRM)					-0.05	-0.05
Facilitating Knowledge Transfer Processes/Channels (CAP_SS)					-0.11	-0.11
Intercept	4.81***	3.77***	1.26**	1.84***	1.39	0.28
Model statistics:						
F-value	16.24***	6.40***	13.61***	9.56***	9.33***	9.06***
R-square	0.20	0.09	0.15	0.11	0.21	0.21

*, ** and *** are indicating 5%. 1% and 0.1% level of significance, respectively.

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