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**COMBINING STOCKS AND FLOWS OF KNOWLEDGE:
THE EFFECTS OF INTRA-FUNCTIONAL AND CROSS-FUNCTIONAL
COMPLEMENTARITY**

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ABSTRACT

In the area of knowledge management and knowledge governance, previous research has mostly focused on either knowledge stocks or knowledge flows of firms or organizational units. Contrary to this work, our study is among the first to integrate these two perspectives in order to shed light on the complementarity effects of different types of knowledge stocks and flows in the multinational corporation (MNC). We investigate intra-functional as well as cross-functional complementarity effects from the perspective of the knowledge recipient. We test the impact of stocks on flows on the benefit that is created for MNC units. Based on a comprehensive sample of 324 relationships between MNC units we find that both types of complementarity create benefits for these units, but that the effects from intra-functional combinations of knowledge stocks and flows are significantly stronger than from cross-functional combinations.

INTRODUCTION

About two decades ago, proponents of the differentiated view of the firm (Bartlett and Ghoshal, 1989; Nohria and Ghoshal, 1997; Doz and Prahalad, 1991) suggested that units of multinational corporations (MNCs) can be distinguished on the basis of their diverse *knowledge stocks* that may eventually build the basis for a firm's competitive advantage (e.g. Wernerfelt and Montgomery, 1988; Barney, 1991; Grant, 1996; DeCarolis and Deeds, 1999). Scholars have also argued that firms exist to share and capitalize on their knowledge (Teece, 1982; Spender, 1996; Kogut and Zander, 1993). As a consequence, in recent years a large number of studies have focused on the question of how *knowledge flows* within the MNC create benefits for the recipient and ultimately lead to value creation in the MNC (e.g. Szulanski, 1996; Simonin, 1999; Tsai, 2001; Minbaeva *et al.*, 2003; Martin and Salomon, 2003; Ambos *et al.*, 2006). Many of these studies (implicitly) assume that the benefit created from knowledge flows is a function of how much knowledge an organizational unit receives and have disregarded knowledge stocks (Simonin, 1999; Tsai, 2001; Foss and Pedersen, 2002; Hansen and Lovas, 2004). Collectively, the MNC literature has mainly taken either a stock-based view or a flow-based view and rarely discussed the mechanisms behind the combination of knowledge stocks and flows (Doz *et al.*, 2001; Foss, 2006; Foss and Pedersen, 2004).

In this paper, we seek to shed light on the *intra- and cross-functional complementarity effects* of knowledge stocks and flows in MNC units. The main logic of our study (and the formulated hypotheses) rests on the argument that the combination of knowledge stocks and flows should provide increased benefits for the recipient units. We propose two general options for complementarity effects: (1) intra-functional complementarity, where knowledge combination takes place *within* value chain functions; and (2) cross-functional complementarity, where knowledge is combined *across* value chain functions.

In prior literature, investigators of knowledge flows within organizations have argued for an inherent benefit to a firm from knowledge flows (Hedlund, 1986, Bartlett and Ghoshal, 1989). But it is not clear which knowledge inflows have to meet what kind of knowledge stocks in order to create benefits for the organization (Foss, 2006; Foss and Pedersen, 2002). Research on knowledge stocks of MNC units has centered on knowledge assets as a source of capabilities and subsidiary-specific advantages (e.g. Kuemmerle, 1999; Rugman and Verbeke, 2001), but has largely neglected the question of which kind of inflows may enhance these units' knowledge creation potential (see also Ambos and Ambos, 2007). Notable exceptions include Holm and Pedersen (2000), Almeida and Phene (2004) and Cantwell and Mudambi (2005).

In order to be able to empirically test different complementarity effects in an MNC setting, where subunits possess a certain level of knowledge stocks and receive inflows from their peer units and HQ, we adopt a simple approach to complementarity. We build on Buckley and Carter's (2004) idea that complementary knowledge is dispersed knowledge whose value is enhanced by combination and we present complementarity as a notion of fit between pieces of the firm's knowledge structure (Lyles and Schwenk, 1992). The way in which knowledge is combined in our context – i.e. flows of subunit A's knowledge to the knowledge stocks of subunit B – is similar to what Buckley and Carter (2004) call “additive complementarity”.

The contribution of this research lies in showing that benefits created from knowledge combination are greatest when stocks and flows are complementary, as our theoretical understanding of how incoming knowledge is linked to existing knowledge stocks is, to date, scarce and fragmented (Foss and Pedersen, 2004). Two broad streams of literature guide our thinking. First, the literature on absorptive capacity, which posits that a large repository of

knowledge stocks will make it easier to benefit from incoming knowledge flows (Cohen and Levinthal, 1990; Zahra and George, 2002; Lane *et al.* 2001). Second, the idea of value chain interdependencies, which argues that non-substitutive relationships – where sender and recipient fulfill different functional tasks – are prone to create valuable combinations of stocks and flows (Porter, 1980; Buckley and Carter, 2004; Postrel, 2002; Andersson *et al.*, 2008).

Building on a sample of 324 knowledge relationships between organizational units in 48 European MNCs, our results demonstrate that knowledge stocks and flows do indeed complement each other as they create greater benefits for the recipient units and that both intra- and cross-functional complementarity have a positive impact. In general, these findings are in line with the arguments on absorptive capacity, but also support proponents of value chain interdependencies. However, the benefits from intra-functional complementarity (i.e. combining stocks and flows from the same function) are three to seven times higher than from cross-functional complementarity (i.e. combining stocks and flows from different functions). We conclude that knowledge combination from different functional areas certainly has value creation potential, but it seems easier to realize the benefits from knowledge inflows within the same area. Our results highlight the important difference between generating knowledge flows within the MNC and actually realizing benefits from complementary knowledge (see Ambos and Ambos, 2009). We also discuss the broader implications of our findings for the knowledge-based theory of the MNC (Hedlund, 1994; Kogut and Zander, 1992, 1993; Zander and Kogut, 1995; Grant 1996, Easterby-Smith and Lyles, 2003).

THEORETICAL BACKGROUND

The Role of Knowledge Stocks and Flows in the MNC

Knowledge *stocks* are accumulated knowledge assets that are internal to an organizational unit, e.g. a subsidiary, and *flows* are knowledge streams occurring between subsidiaries or

between subsidiaries and headquarters (HQ) over a specific period of time through a wide range of media (DeCarolis and Deeds, 1999; Schulz, 2003). Large parts of the literature on MNCs place an emphasis on stocks of knowledge. 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 are difficult for competitors to imitate. 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 the MNC context, several factors are likely to determine the value of a particular knowledge stock. These have been categorized into factors pertaining to the location of the knowledge in the organizational network, such as the unit's geographic location (e.g. Porter, 1980; Kuemmerle, 1999), its mandate (e.g. Birkinshaw and Morrison, 1995), or its activity structure (e.g. Andersson *et al.*, 2008), and knowledge-specific characteristics such as tacitness, observability and teachability (Kogut and Zander, 1992; Birkinshaw *et al.*, 2002).

Recently, scholars have stressed that exploiting dispersed knowledge stocks to their fullest extent necessitates more than simply possessing and utilizing these stocks in individual units (Martin and Salomon, 2003; Hansen and Lovas, 2004). Knowledge has to flow across unit boundaries in order to be combined with other knowledge and create benefits for the recipient. Knowledge combination is defined along these lines as the process of bringing together 'elements previously unconnected or by developing new ways of combining elements previously associated' (Nahapiet and Ghoshal, 1998, p. 248). To provide the potential for knowledge combination in the MNC, dispersed organizational units develop specific activity profiles due to assignments from headquarters, self-induced developments, and local environmental determinism (Birkinshaw and Hood 1998). Hence, subsidiaries are linked with

HQ and peer units through collaborative or substitutive relationships (Andersson *et al.*, 2008) that determine how and where knowledge flows are used. Researchers have also acknowledged that flows do not “automatically” create value, as they require a fit between organizational contingencies, such as task-context, distance or transmission channels and knowledge characteristics (Haas and Hansen, 2005; Ambos and Ambos, 2009; Foss and Pedersen, 2002).

Unfortunately, we know very little about the interaction between the knowledge stocks and flows of dispersed MNC units, other than at a relatively abstract level (DeCarolis and Deeds, 1999; Bontis *et al.*, 2002; Buckley and Carter, 2004). While research on the benefits of combining knowledge stocks and flows is rare, there is consequently also a lack of research investigating the extent to which different types of knowledge stocks and flows can be combined. Questions that remain unanswered include: Do knowledge stocks and knowledge flows really create benefits by interacting with each other? Is it all kinds of stocks and flows or only particular combinations of stocks and flows that create benefits in their interaction? How can firms proactively support knowledge flows that create benefits for organizational subunits?

Our study investigates the complementarity of knowledge stocks and flows by focusing on the *combination of dispersed knowledge within and across value chain functions*. In line with previous work (Schulz, 2003, p. 441), we assume that knowledge in organizations flows along pathways of relevance, so that ‘receiving subunits are likely to seek and select knowledge relevant to their operations, and knowledge-providing subunits are likely to send knowledge to subunits to which this knowledge might be relevant’. In this context, certain pieces of the knowledge structure may act as a lock-key mechanism to create value (Lyles and Schwenk, 1992; Foss, 2006). The perspective we take is that of a focal subunit that possesses a certain

level of knowledge stocks and also receives knowledge inflows from other units. Thus, we view the organizational units as nodes that possess and receive specialized knowledge. We distinguish knowledge stocks and flows into downstream and upstream activities. Downstream knowledge stocks, in our definition, include know-how in the areas 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 that allows the organizational unit “to do something smoothly and efficiently” (Kogut and Zander, 1992, p. 386).

The Benefits Created by Knowledge Stocks and Flows

Both knowledge stocks and knowledge flows have been recognized as sources of value creation, but despite a number of empirical investigations (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 stocks or flows. While the above-mentioned studies suggest that not every transfer is beneficial per se and that the relevance or application in a new context will depend on contextual contingencies, the potential of “knowledge combination” has not been sufficiently explored in the MNC context (Kogut and Zander, 1993; Ghoshal and Moran, 1996; Nickerson and Zenger, 2004, Fleming *et al.*, 2006).

In addition to the scarcity of research on the benefits of combining knowledge stocks and flows, there is, as a consequence, also a lack of research investigating the extent to which different *types* of knowledge stocks and flows can be combined. Although the concept of absorptive capacity is at the center of many studies’ investigations (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Zahra and George, 2002, Lane *et al.*, 2006; Volberda *et al.*, 2010), our understanding of how incoming knowledge is linked to existing knowledge stocks

is scarce. And, for the most part, the ability to benefit from knowledge is contingent on prior knowledge in the same functional area. Yet a firm's ability to create new knowledge from existing stocks and flows also depends on combining knowledge elements from different value chain activities, e.g. from marketing and R&D (Buckley and Carter, 2004).

In short, we argue that benefits are created at the interface between stocks of knowledge and flows of knowledge. Generally, the benefits from knowledge transfer for the recipient should be greater if the inflows of knowledge and existing stocks of knowledge are complementary. Flows and stocks of knowledge are complementary if there is a fit between different elements of the knowledge structure, so that knowledge that is available in different places within the firm can be combined to facilitate the firm's actions in one of these locations (Buckley and Carter, 2004). This fit could be created in an additive way, so that inflows of marketing knowledge add to a unit's portfolio of marketing knowledge and create benefits. For example, a subunit that has a lot of knowledge about its customers' preferences will be able to utilize marketing ideas from other markets to optimize local adaptation of a new product, thus benefitting from intra-functional complementarity. Alternatively, there is the possibility that incoming knowledge flows are substitutes (Tzabbar *et al.*, 2008) and it is more favorable to combine knowledge from different value chain functions that are not substitutable. We will explore the logic of these two complementarity situations below.

Intra-functional Complementarity of Knowledge Stocks and Flows

One of the most important lines of thought that systematically connect 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 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. For example, when a MNC unit has a high level of technical knowledge, the transfer of advanced user needs and wishes 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 provides a larger pool of knowledge on which to draw, both in terms of new solutions and in order to understand the depth of the transferred knowledge. The MNC unit would, on the other hand, be unable to reap the benefits of the transferred knowledge if it had no prior knowledge stocks whatsoever on which to draw.

Although Cohen and Levinthal do not discuss the micro-processes of knowledge combination and propose a rather crude empirical measure (R&D spending), the concept of absorptive capacity has been at the center of the academic debate over the last two decades (for reviews see Zahra and George, 2002; Lane *et al.*, 2006; Volberda *et al.*, 2010). In this stream of thinking, scholars argue 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 stocks relative to its peers. While MNC units may 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 the creation of benefits. However, 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 mean (Shenkar and Li, 1999), but the answer to this question is highly significant to 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, know-how pertaining to the same functional area, e.g. marketing, within one firm is relatively related. It is also appropriate to assume that the necessary level of diversity exists when two MNC units located in different countries transfer knowledge of the same 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 benefits from knowledge inflows in the respective area as it provides the necessary absorptive capacity. We suggest that this is true for know-how regarding downstream (i.e. marketing and distribution) as well as upstream (i.e. technology and purchasing) activities and develop the following two hypotheses:

H1a: Under conditions of high knowledge stocks in **upstream** activities: the greater the inflow of **upstream** knowledge, the greater the benefits for **upstream** activities.

H1b: Under conditions of high knowledge stocks in **downstream** activities: the greater the inflow of **downstream** knowledge, the greater the benefits for **downstream** activities.

Cross-Functional Complementarity of Knowledge Stocks and Flows

A different stream of thinking builds on the idea of value chain activities and linkages of functions within the MNC (e.g. Porter, 1980; O'Donnell, 2000). These linkages should also result in reciprocal knowledge relationships or dependencies. As the MNC is characterized by complex interdependencies and a distribution of activities across several subunits, scholars have claimed that 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 and Zander, 1992; Ghoshal and Moran, 1996).

The challenge of combining existing knowledge stocks with incoming flows is likely to be greatest when substantially different knowledge, from different functional areas, is involved (Ambos and Ambos, 2009; Haas and Hansen, 2005). However, combining knowledge from different areas is likely to offer greater potential for finding novel and interesting insights, although it entails higher risk. Kogut and Zander (1996) suggest that specialization and differentiation are more efficient for knowledge acquisition, but mutual understanding and homogenization of knowledge facilitate knowledge exploitation. In short, the learning potential from other value chain functions is greater, but it may be more difficult to realize the benefits from this incoming knowledge.

Amongst the few scholars that have investigated knowledge complementarities, Postrel (2002) has attempted to identify the optimal division of knowledge in the area of new product development based on the thinking that certain processes in the organization provide “docking points” that make the use of incoming knowledge easier and more economical. We suggest that value chain interlinkages provide such “docking points”. For example, R&D units might profit substantially from new incoming knowledge regarding customer preferences and

behavior, as this helps in adjusting R&D efforts. Similarly, 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.* (2008) 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.*, 2008).

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

H2a: Under conditions of high knowledge stocks in **downstream** activities: The greater the inflow of **upstream** knowledge, the greater the benefits for **downstream** activities.

H2b: Under conditions of high knowledge stocks in **upstream** activities: The greater the inflow of **downstream** knowledge, the greater the benefits for **upstream** activities.

METHODOLOGY

Sampling

We used the European Top 500 companies list as our sample frame¹. The research plan involved data collection at two levels; on the level of the headquarters (HQ) as well as on the level of the 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 at the same time using directly proportional

¹ Based on revenues.

strata of 10 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 revenue was approached. Starting with the largest corporations, senior managers from each HQ were contacted and asked to co-operate. Upon agreement, each was asked to nominate four subsidiaries that could participate in the study. This sampling procedure led to a final target sample of 300 units, i.e. 60 HQ and a total of 240 subsidiaries. A standardized survey was sent out to all participants by post. Respondents at regular subsidiaries were general managers, while respondents at larger subsidiaries were functional heads. For HQ, respondents were members of the top management team that liaises with subsidiaries, e.g. Heads of the International Division. The survey aimed to ensure a high response rate through two follow-up rounds and by promising to provide participants with the results. Despite these efforts, and the initial agreement of HQ, it was impossible to collect responses from all the firms in time. The final sample consisted of 162 MNC units belonging to 48 companies. Of these, 38 HQ and 124 subsidiaries participated and reported on multiple knowledge transfer relationships within their organization. Each HQ reported on its knowledge transfer practices with two subsidiaries, and each subsidiary reported on its interactions with HQ and a peer subsidiary. In total, this led to a total of 324 transfer relationships.

The sample composition shows significant variance. The final sample represents leading MNCs from diverse industries, such as manufacturing (56%), finance and insurance (21%), and other services, including consulting companies (11%). The surveyed units operate in 29 countries. The smallest distance between units is 0, i.e. a case where HQ and subsidiaries are located in the same city. The average HQ employs 1,019 employees, whereas the average number of subsidiary personnel is 638. While 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, whereas the remainder originated from a merger or acquisition.

The unit of analysis in this study was a *dyadic knowledge relationship* between two organizational units, e.g. between HQ and a subsidiary or between two subsidiaries. As only 54% of the targeted MNC subunits returned their questionnaires, there is a potential for non-response bias. We assessed this potential by examining 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. We also conducted an extrapolation test between early and late respondents. The results suggest that the likelihood of non-response bias is minimal (Armstrong and Overton, 1977).

Statistical approach

While we are not developing hypotheses for the determinants of knowledge stocks and flows, we still believe that different determinants like an MNC unit's size or country location have a bearing on both the level of knowledge stocks and flows. This might potentially create a problem of endogeneity. By consequence, we endogenize our key variables, i.e. knowledge stocks and flows, by including instrument variables. At the same time, we model potential complementarity, i.e. beneficial combinations of stocks and flows, as interaction effects. This approach mirrors our contingency view on complementarity, i.e. that there has to be a fit between knowledge stocks and flows (see also Venkatraman, 1989).

Our econometric approach is a simultaneous equation estimation using three-stage least squares (3SLS). We use a number of instrumental variables to produce consistent estimates and generalized least squares to account for correlation in potential disturbances across equations. Stage 1 of our procedure can be interpreted as producing instrumental values of our two endogenous variables which, in our case, are 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, benefits from knowledge flows (Nickerson and Hamilton, 2003). By doing so, we avoid the risk of endogeneity problems. This is warranted since endogeneity problems might arise due to measurement errors that may occur given the abstract nature of many aspects of knowledge and because we cannot *a priori* rule out the presence of unobserved variables that could have an effect on both knowledge stocks, flows, and the benefits for the unit. If we were to estimate our model using OLS under such circumstances, we would run the risk of obtaining biased coefficients (as revealed by a Hausman test of endogeneity). Therefore, a better estimation method in this case is 3SLS, in which the endogenous regressors – knowledge stocks and flows – are regressed on all of the exogenous variables in the first stage and their predicted dependent variables are used in the second stage.

Measurements

The data used in this study came mostly from a questionnaire, but the study also includes secondary data, e.g. from Eurostat and World Competitiveness Report. As HQ's 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 with managers involved in the research topic. Several amendments, mainly in wording, were made 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.

To minimize the potential for common method bias, we put several safeguards in place (e.g. Podsakoff *et al.* 2003, Chang *et al.* 2010). As a procedural mechanism, we ensured respondent anonymity during the data collection phase. This usually helps prevent consistency motif and

social desirability. Most of our measures in this study are based on existing, well-tested scales (e.g. adopted from Gupta and Govindarajan, 2000) and additional measures went through a thorough pre-testing process in which we validated the scales (e.g. Lindell and Whitney 2001; Podsakoff *et al.* 2003). In addition, dependent and independent measures were distributed throughout the questionnaire so that it was virtually impossible for respondents to detect hypothesized relationships. Finally, we emphasize that our 3SLS model integrates objective measures (often based on secondary data) with perceptual measures. It is a highly complex model which makes common method bias less likely (Chang *et al.*, 2010). In addition, the model uses interactions. Such complex models with interaction effects are highly unlikely to suffer from common-method variance (Siemsen *et al.*, 2009; Kotabe *et al.* 2003).

The following section briefly introduces the operationalization of our variables.

Dependent and Independent Variables

Upstream and Downstream Benefits. Two variables were created that capture the benefits of knowledge since we distinguish between impact on upstream and downstream activities. The benefits from knowledge transfer created for the recipient was measured using 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 (Cronbach alpha = 0.84). The benefits for upstream activities were based on technology know-how and purchasing know-how (1 = not at all; 7 = a very great deal) (Cronbach alpha = 0.74; see also Gupta and Govindarajan, 2000).

Knowledge Stocks. The recipient unit's knowledge stocks relative to the knowledge stocks of the sender (i.e. HQ or a subsidiary) in different knowledge domains was used as a measure. In line with Gupta and Govindarjan (2000), the knowledge domains mirror those used for the

benefit measure. Cronbach alphas are 0.69 and 0.76 for downstream and upstream knowledge stocks, respectively.

Knowledge Inflows. 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 and Govindarajan's (2000). The Cronbach alpha values are 0.84 and 0.78 for downstream and upstream knowledge inflows, respectively.

Determinants of Knowledge Stocks (Instruments)

Amongst others, Dierickx and Cool (1989) have pointed to the difficulty of clearly identifying the drivers of a knowledge accumulation process that leads to a high level of knowledge stocks. We use a number of variables as determinants of knowledge stocks that we derived from previous literature. These measures are a means of capturing the quality and amount of knowledge in the external business environment, as well as some unit-level characteristics. A number of scholars have reported that host country- and industry-specific factors may impact a unit's stocks of know-how and capability development (Porter 1980; Asmussen *et al.* 2009).

We proxied the available scientific know-how in a country by using data on the number of **scientific papers** published in a country per capita. We used data from World Bank for this measure. Units that operate in such environments are more likely to have larger knowledge stocks and this variable has worked well as an instrument of knowledge stocks in previous studies (Asmussen *et al.*, 2011). In addition to the available know-how in a country, the level of **competitiveness of the unit's location** could be a predictor of the unit's knowledge stocks (Asmussen *et al.*, 2011). Country competitiveness was assessed using the World Competitiveness Index. We created a dummy variable, taking the value of 1 where the focal unit's country ranks higher on the competitiveness scale than the knowledge sender, and 0

where this is not the case. The increase in **revenues per employee** in the industry was used as a proxy for the learning and productivity gains in the industry of the focal unit that are likely to impact the accumulation of knowledge stocks. This was calculated based on aggregated industry-level data from the Orbis database for all European countries and referred to the increase (or decrease) between 2002 and 2004. In addition to the external environment, unit-specific variables were used as instruments for knowledge stocks. First, **unit size** is a simple, objective instrument and was measured as the (logged) number of employees at the focal unit. Second, a dummy variable characterizing the **type of unit**, i.e. if it is the HQ (1) or a subsidiary (0), served as a proxy for the unit's formal position.

Determinants of Knowledge Flows

Prior research has identified many antecedents of knowledge flows that can be clustered as structural features of the unit, such as its mandate or network position (Tsai, 2001; Birkinshaw and Hood 1998; Gupta and Govindarajan, 2000), or relational elements, such as reciprocity (Monteiro *et al.*, 2008) or motivation (Osterloh and Frey, 2000). With regard to the instruments for knowledge flows, to a large extent we captured mechanisms and processes that had been highlighted by previous literature for fostering knowledge exchange (Becerra-Fernandez and Sabherwal, 2001; Leonard-Barton, 1995).

First, we captured **Personnel Coordination Mechanisms** (cf. Gupta and Govindarajan, 2000; Hansen *et al.* 1999; Ambos and Ambos, 2009). The operationalization of this variable was adopted from Gupta and Govindarajan (2000). Cronbach alpha=0.76. Second, **Technological Infrastructure** is supposed to have a bearing on knowledge flows (Leonard-Barton, 1995). To assess the unit's ability to use technical infrastructure for inter-unit knowledge transfer, a multiple-item construct was created based on Becerra-Fernandez and Sabherwal (2001; Cronbach alpha = 0.83). Third, and related to the technological infrastructure, we captured the

usage of different channels of knowledge transfer. We named this variable **Facilitating Knowledge Transfer Processes/Channels**. It is based on four items and it captures the use (vs. mere existence) of knowledge-sharing tools (Cronbach alpha = 0.776). To capture the degree of similarity between the partners' business practices we adopted the measure from Simonin (1999) to assess the **Similarity of Business Practices**. Respondents were asked to respond to the statement "Generally, business practices and operational mechanisms are very similar" on a seven-point scale ranging from "I strongly disagree" to "I strongly agree".

Controls

In addition to the instruments, we used control variables in all equations. To control for the **Direction of Knowledge Flow**, we used a dummy variable for lateral (subsidiary to subsidiary) knowledge flows as opposed to vertical knowledge flows between the HQ and the subsidiary. We also controlled for the **Geographic Distance** between knowledge sender and recipient using the logged number of air miles between the units. Respondents were also asked to indicate on seven-point scale (1= I strongly disagree, 7 = I strongly agree) whether "Our company uses technology that allows employees to collaborate with other persons inside the unit". We named this variable **Collaborative Technology**.

RESULTS

Descriptive Statistics and Statistical Safeguards

The correlation coefficients and descriptive data (mean values, standard deviations, and normality statistics) on all variables are provided in Table 1. The two highest correlations are between the two types of knowledge stocks ($r=0.61$) and the two types of flows ($r=0.69$), respectively. However, in order to detect potential problems of multicollinearity, we investigated the correlation coefficients among the independent variables in the models (i.e. all variables other than the two types of stocks and the two types of flows that are all

endogenized in our 3SLS model). None of the correlations among exogenous independent variables are above the commonly reported threshold of 0.5, indicating a low likelihood of multicollinearity problems. However, since some of the variables have bivariate coefficients above 0.4, we re-ran the models without these variables as robustness tests. The results were qualitatively the same.

***** Insert Table 1 about here *****

To assess the potential of common method bias, we conducted a Harman's one-factor test (Podsakoff *et al.*, 2003). The results showed that our items did not produce one single emerging factor. Items from the different constructs also separated well into different constructs and undue cross-loadings were absent. This leads us to conclude that our results are not adversely impacted by common method variance.

Results

The results are presented in Table 2. Our system of equations converges quickly on stable estimates. Model fit is acceptable with significant F-values ($p < .01$) and R-Squared values ranging from 0.11 to 0.27 for all specifications. The first two columns (in Table 2) show the unstandardized coefficients of the predictors of upstream knowledge stocks and downstream knowledge stocks, respectively. There is support for the idea that external and more structural variables at industry-level (i.e. revenue per employees) and country-level (i.e. scientific papers per capita and country competitiveness) account for the level of knowledge stocks. Unit size does have an effect on downstream stocks. Finally, where the unit is a HQ, knowledge stock levels are found to be higher for both upstream and downstream activities.

Our results confirm that the instruments work well as a group, accounting for an acceptable 11% to 19% of the variance in the endogenous regressors (as reported in Table 2).

Furthermore, to test for over-identifying restrictions we regressed the residuals from the two benefits equations on the instruments for the model (Sargan, 1958). Model fit in these two regressions is very low ($R^2 = 0.02$) for both the residuals of upstream and downstream benefits, and none of the predictors were statistically significant. We also inspected the bivariate correlations between instruments and residuals, all of which were insignificant and close to zero. In combination, these tests do not provide absolute proof of the complete absence of endogeneity bias, but they do suggest that the problem has been addressed in our model.

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 are positive antecedents of knowledge inflows, with the exception of facilitating knowledge transfer, which does not seem to have an effect on downstream knowledge inflows. Hence, consistent with previous findings, personal coordination mechanisms, technical infrastructure, and similar practices between senders and receivers increase knowledge inflows. Contrary to stocks of knowledge, HQs appear to receive less knowledge than subsidiaries.

***** Insert Table 2 about here *****

The last two columns show the effect of the direct and combined effects of the instrumental variables of stocks and flows on benefit creation. Column five shows that neither upstream stocks nor upstream inflows or downstream inflows have a direct effect on benefits for upstream activities. However, both interaction terms representing hypothesis 1a and 2a feature positive and significant coefficients. Hence, upstream knowledge stocks create benefits for upstream activities only where they are combined with knowledge inflows – irrespective of whether these are knowledge inflows in the same activity area (upstream; $\beta=0.21$, $p < 0.001$)

or if they are downstream inflows ($\beta=0.03$, $p < 0.05$). However, the positive effect of H1a is roughly seven times the effect of H2a². The difference is also statistically significant at $p < 0.01$. Of the control variables, only lateral 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 benefits for downstream activities. Results are qualitatively similar to the model predicting upstream benefits. Downstream activities do not benefit from any inflows, either downstream inflow or upstream inflow, although downstream stocks are, in themselves, beneficial for downstream activities. The combination of downstream stocks and the inflows is what benefits the downstream activities most and this provides support to both H1b and H2b. While the combination of downstream stocks and upstream inflows is positive and significant ($\beta=0.06$, $p < 0.001$), the combination of downstream stocks and downstream inflows is even stronger ($\beta=0.21$, $p < 0.001$), again with the difference being statistically significant at $p < 0.01$. In fact, the combination of downstream stocks and flows has a positive effect that is three times stronger than when downstream stocks are combined with upstream knowledge inflows. Among the control variables it is only the lateral transfer that proves significant, indicating that lateral knowledge transfer creates fewer benefits for downstream activities than hierarchical transfer.

DISCUSSION, LIMITATIONS AND CONCLUSION

Our study is one of the few attempts to explicitly investigate the complementarity between different types of knowledge stocks and flows. Our findings have several implications for our theoretical understanding of knowledge management in MNCs and for the knowledge-based theory of the firm:

² The coefficients are comparable since the measurement scales are identical.

First, we find that inflowing knowledge has to meet knowledge stocks in order to produce benefits for the knowledge-receiving unit. Our research shows that a strong focus on either stocks (e.g. Dierickx and Cool, 1989) or flows (e.g. Foss and Pedersen, 2002) falls short of important mechanisms that explain how benefit for the recipient is generated, since the combination of stocks and flows is the most important driver of benefit creation. Future research should thus avoid a narrow focus on either stocks or flows, and instead investigate the specific conditions for knowledge combination.

Second, our findings show that MNCs create the greatest benefits when knowledge stocks and flows are combined *within* certain functions. This effect is very consistent and strong in our data. The finding is in line with previous research arguing that knowledge sharing within functions is dependent on the unit's absorptive capacity. Similar to Lane and Lubatkin (1998), we assume a student-teacher relationship between knowledge recipients and senders, so that inflows in the same area are connected to existing stocks. However, previous research has also suggested that units operating within the same domain might perceive the other unit as a competitor (substitutive relationship between sender and receiver, e.g. Andersson *et al.* 2008) and hence refrain from knowledge transfer. We conducted a sub-sample test to compare the intensity of intra-functional with cross-functional knowledge flows. Interestingly, in our data we find no evidence for the claim that there are significantly fewer transfers within functions than across functions. This could mean that firms have effective incentive systems in place and are indeed able to motivate their units to share knowledge. But we could also conclude that problems of competition in substitutive relationships might be overstated, given the strong effects on the benefits and the fact that we do not find differences in absolute flows within and across functions. This pattern suggests that knowledge does flow along pathways of relevance (Schulz, 2003) and combining knowledge within functions is highly relevant to creating benefits for the receiving unit.

Third, our findings show that the combination of knowledge stocks and flows *across* functions also produces benefits. This effect, however, is 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). Cross-functional knowledge sharing, arguably, is largely non-substitutive. Thus, there is significant potential for benefits that can be derived from combining stocks and flows across functions. And it has been argued in previous research that novel ideas and insights are likely to originate from different functions or environments (Ambos and Ambos, 2009; Morosini *et al.*, 1998). However, our results show that, compared to the intensity of cross-functional knowledge flows, the level of realized benefits is much lower. It therefore seems to be more difficult to actually connect diverse knowledge stocks and flows. The reasons for this may lie in a lack of understanding, increased ambiguity or functional silos (Simonin, 1999, Szulanski, 1996).

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 where they are located at different stages of the value chain (e.g. Gupta and Govindarajan, 2000). Our data shows that cross-functional knowledge sharing is much less beneficial than intra-functional sharing. Equating cross-functional sharing with important complementarity effects is, therefore, misleading and might create substantial costs for “useless” transfers when implemented within firms. At this point, however, we must highlight that our study took a relatively broad approach, defining functions as upstream (technology and purchasing know-how) and downstream (marketing and distribution know-how). This breadth might drive complementarity even when knowledge stocks and flows are combined within functions. Also, in the context of MNC units, our data captures knowledge stocks and flows coming from and residing in different units that are embedded in different local market

contexts and exposed to different environmental opportunities and threats. Therefore, the knowledge elements are still very likely to exhibit “differences” even if they belong to the same function. Future research may shed more light on more fine-grained complementarities within and across functions and also investigate the extent to which firms are able to differentiate their costly knowledge transfer mechanisms.

Finally, our results suggest that firms do often engage in relatively “unproductive” knowledge transfer, that is, knowledge transfer that does not produce substantial benefits at the receiving unit. This complements previous literature, which has focused on the tremendous difficulties that firms face when trying to create benefits from knowledge transfers (e.g. Ambos and Ambos, 2009). Our results suggest that, ultimately, the benefits of knowledge transfer and sharing cannot be taken for granted, even if the units that engage in the sharing overcome the barriers to transfer in the first place (Szulanski, 1996). Hence, ambiguities and misinterpretation of complementarities might lead to “useless” flows, especially across functions, which is supposed to be particularly costly. Flows leading to relatively low levels of benefits might be the result of unspecific promotion of knowledge transfers or the existence of standardized transfer-facilitating tools and mechanisms. Thus, companies have to focus their knowledge management mechanisms to better support integration of cross-functional knowledge flows.

Based on our findings, it may be necessary to reconsider the interpretation of the positive theory of the MNC (Ghoshal and Moran, 1996). 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, especially across functions (Kogut and Zander, 1992). We suggest that MNCs might rather be conceived as organizations that still reap a more substantial proportion of the total benefits of knowledge

sharing from intra-functional sharing. The reason is not that cross-functional sharing does not occur but that, according to our data, it is much more difficult to genuinely derive substantial benefits from such a transfer. This is an important qualification of the theory, with a number of implications. For example, one could argue that knowledge-sharing systems might be or should ideally be relatively function-specific, as the lion's share of complementarity benefits occur within functions. MNCs could be perceived as sets of function-specific knowledge-sharing systems. 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 may also engage in a more detailed differentiation of value chain functions, separating different activities and also incorporating support functions such as IT or HR.

Table 1. Correlation Matrix and Descriptive Statistics (N = 324).^a

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1) Upstream Benefits	1.00																		
2) Downstream Benefits	0.40	1.00																	
3) Upstream Stocks	-0.10	-0.05	1.00																
4) Downstream Stocks	-0.12	-0.02	0.61	1.00															
5) Upstream Inflows	0.38	0.22	-0.24	-0.19	1.00														
6) Downstream Inflows	0.26	0.37	-0.09	-0.12	0.69	1.00													
7) Revenue per Employee	0.05	0.13	0.05	0.05	0.01	0.11	1.00												
8) Scientific Papers Per Capita	-0.06	-0.02	0.07	0.07	-0.14	-0.16	-0.01	1.00											
9) Unit Size	-0.06	0.09	0.11	0.09	-0.16	-0.03	0.21	0.05	1.00										
10) Country Competitiveness	0.09	0.11	0.04	-0.07	0.11	0.18	0.03	0.28	0.05	1.00									
11) Type of Unit	0.06	-0.04	0.44	0.14	-0.25	-0.13	0.01	0.15	0.12	0.03	1.00								
12) Personal Communication Mechanism	0.22	0.30	0.12	0.12	0.13	0.13	0.12	0.03	0.09	0.08	0.24	1.00							
13) Technical Infrastructure	0.17	0.28	0.04	0.07	0.14	0.21	0.05	-0.07	0.03	0.09	0.06	0.31	1.00						
14) Similarity of Business Practice	0.12	0.15	-0.07	-0.02	0.19	0.20	0.03	-0.07	-0.01	0.08	0.04	0.03	0.17	1.00					
15) Facilitating Knowledge Transfer Process/Channels	0.02	0.25	0.05	0.14	0.02	0.14	0.10	0.05	0.14	-0.03	0.04	0.28	0.42	0.22	1.00				
16) Lateral Transfer Dummy	-0.26	-0.26	-0.07	0.01	-0.16	-0.13	-0.01	-0.06	-0.05	-0.10	-0.44	-0.25	-0.03	0.09	-0.02	1.00			
17) Geographic Distance	-0.04	0.01	0.04	0.01	0.02	0.03	-0.15	-0.01	-0.08	0.13	0.05	-0.04	0.01	-0.05	-0.07	-0.04	1.00		
18) Collaborative Technology	0.18	0.22	-0.01	0.06	0.15	0.21	0.07	-0.09	0.03	-0.01	0.07	0.24	0.39	0.10	0.45	-0.03	-0.02	1.00	
Mean	3.76	3.68	4.21	4.29	3.60	3.75	1.43	0.46	631	0.36	0.77	3.72	-0.01	4.63	4.70	0.38	5.55	5.63	
Std. dev.	1.37	1.40	1.11	1.04	1.46	1.48	0.10	0.24	1,147	0.48	0.42	1.23	0.98	1.39	1.36	0.49	2.21	1.02	
Min. value	1	1	1	1	1	1	1.26	0.04	3	0	0	1	-3.08	1	0	0	0	2	
Max. value	7	7	7	7	7	7	1.61	1.06	7,000	1	1	7	2.16	7	7	1	9.2	7	

a) All coefficients above 0.10 are significant at $p < 0.05$

Table 2: 3SLS Model for Benefits Created Through Knowledge Stocks and Flows (N = 324).^a

	Stocks of upstream knowledge	Stocks of downstream knowledge	Inflows of upstream knowledge	Inflows of downstream knowledge	Upstream benefits	Downstream benefits
Revenue per Employee	0.24*	0.15				
Scientific Papers per Capita	0.10	0.14*				
Unit Size	0.01	0.01*				
Country Competitiveness	0.11*	-0.01				
Type of Unit	1.04***	0.20*	-1.09***	-0.68***		
Personal Coordination Mechanisms			0.25***	0.16*		
Technical Infrastructure			0.22**	0.25**		
Similarity of Business Practices			0.17***	0.15**		
Facilitating Knowledge Transfer Processes/Channels			-0.12*	0.03		
Upstream Stocks					-0.10	
Upstream Inflows					0.32	-0.08
H1a: Upstream Stocks * Upstream Inflows					0.21***	
H2a: Upstream Stocks * Downstream Inflows					0.03*	
Downstream Stocks						1.16**
Downstream Inflows					-0.17	0.04
H1b: Downstream Stocks * Downstream Inflows						0.21***
H2b: Downstream Stocks * Upstream Inflows						0.06***
Control Variables:						
Lateral Transfer					-0.56***	-0.49***
Geographic Distance					-0.05	-0.02
Collaborative Technology					0.10	-0.03
Intercept	4.56***	4.15***	1.60***	1.82***	1.04	1.95
Model statistics:						
F-value	15.33***	8.13***	12.00***	7.62***	14.89***	10.21***
R-square	0.19	0.11	0.16	0.11	0.27	0.25

a) *, **, and *** indicate a 5%, 1%, and 0.1% level of significance, respectively.

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