

R&D Subsidiary Embedment: A Resource Dependency Perspective

Christopher Williams*

Strategy and Marketing Section
Amsterdam Business School
Universiteit van Amsterdam
Plantage Muidersgracht 12
1018 TV Amsterdam
The Netherlands
Tel: +31-20-525 7385
Fax: +31-20-525 4182
E-mail: c.williams@uva.nl

Brigitte Ecker

Joanneum Research Forschungsgesellschaft mbH
Institute of Technology and Regional Policy - InTeReg
Sensengasse 1
A-1090 Vienna
Austria
Tel: 43-1-5817520-2833
Fax: 43-1-5817520-2820
Email: brigitte.ecker@joanneum.at

*Author for correspondence

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ABSTRACT

We investigate embedment of overseas R&D subsidiaries within networks of innovation. We examine empirical studies of both general MNC subsidiary embedment and R&D subsidiary embedment in particular, and find the following: (1) a large variation in the operationalization of embedment (e.g., frequency of communication versus depth of integration versus direction of communication); (2) scant attention to the nature of differences between external actors (types of actors, including local and international). We consider this a weakness, especially given the importance of embedment in R&D subsidiaries whose scientists and engineers rely on external international networks of innovation. Thus, we draw on resource dependence theory (Pfeffer and Salancik, 1978) to argue how embedment of overseas R&D subsidiaries of multinational corporations (MNCs) should be treated as a more multi-faceted and complex phenomenon than has been apparent to date. We provide specific guidance on how to improve the operationalization of the external embedment construct and recommend the following: (1) formative development of the embedment construct for R&D subsidiaries; (2) multi-level treatment of the embedment construct (global – regional – national – sub-national); (3) reporting multiple models to show the effects of embedment with various actors; (4) empirical fieldwork to investigate the links between resource dependency, embedment and R&D subsidiary performance.

Key words: Subsidiary embedment, R&D networks

1. INTRODUCTION

Recent trends in the globalization of innovation have placed an emphasis on overseas R&D subsidiaries as critical sources of knowledge for the MNC (Dunning and Narula, 1995; Kuemmerle, 1997; Santangelo, 2002). Such subsidiaries become deeply embedded within national and international innovation systems, interacting with multiple actors both locally and globally, outside of the MNC. This embedment is argued to be critical to the performance of the unit, and of the innovative potential of the wider MNC (Andersson et al., 2001). However, empirical and theoretical studies have been somewhat limited with respect to their treatment of the nature of embedment. Whilst some have treated embedment as an antecedent to technological performance (e.g., Frost, 2001; Andersson et al., 2001), others have highlighted subsidiary embedment as a determinant of knowledge creation and knowledge exploitation capabilities, and thus as a precursor to subsidiary power and influence (Cantwell and Mudambi, 2005; Mudambi and Navarra, 2004). To a large extent, these studies treat embedment in general terms rather than in terms of patterns of structural configuration. Moreover, most of these works do not show which external actors matter, and why. We consider this as a weakness, especially given recent empirical research on R&D subsidiaries that has shown how a firm-level factors impact these units' external structural inter-connections across a range of actors in different ways (Williams and Nones, 2009).

In this paper we address this weakness by examining the question that is central to the reality of R&D subsidiary embedment: With whom, and for what reasons, should an R&D subsidiary become embedded? Our approach is first to analyse a range of studies of external embedment of subsidiaries of all types. We also consider studies of external embedment relating specifically to subsidiaries engaged in R&D. We find that many empirical articles on subsidiary embedment assume a simplistic or uniform set of structural connections and relationships. Moreover, embedment is likely to be reflected as a pattern of resource

interdependencies. The actors that matter most to an R&D subsidiary will be a function of the importance and availability of the innovation-specific resources they contain. Thus, secondly, we draw on resource dependence theory (Pfeffer and Salancik, 1978) and utilize the argument that organizations are controlled by actors in their external environment for the specific instance of the overseas R&D subsidiary of the MNC.

The value added of the current paper is to provide the foundations for a new framework for operationalizing the external embedment of R&D subsidiaries. Drawing on resource dependency theory as a theoretical platform, we provide specific guidance on how to improve the operationalization of the external embedment construct for R&D subsidiaries. Finally, we also provide specific recommendations to researchers involved in operationalizing subsidiary embedment in general and suggest how our model may be tested in empirical fieldwork.

2. BACKGROUND

A growing stream of literature has emerged examining the nature and consequences of embedment of international subsidiaries of MNCs (e.g., Andersson and Forsgren, 1996; Birkinshaw and Hood, 1998; Andersson et al., 2002; Ambos and Schlegelmilch, 2004; Garcia-Pont et al., 2009). A central theme in this stream of literature is the social interaction between an overseas subsidiary and actors in the subsidiary's external environment. The literature maintains that this social interaction (the degree of which is assumed to be a key determinant of the subsidiary's external embedment¹) is important to allow the subsidiary (and hence the MNC) to access dispersed sources of knowledge (Frost, 2001; Andersson et al., 2005) and acts as a driver of both subsidiary and MNC performance (Andersson et al., 2002). In this line, several scholars (for an overview see Andersson et al., 1998) have pointed

¹ We use the terms embedment and embeddedness interchangeably in this paper

out that the unit's performance is dependent on its ability to obtain valuable resources from its environment. Furthermore, embedment can be a source of influence for the subsidiary within the MNC (Birkinshaw and Hood, 1998). According to Narula (2003: 77): "the more embedded the foreign subsidiary, and the greater the intensity of the value-adding activity, the greater the amount of R&D activity." Embedment is seen as important to encouraging competence-creating mandate for the subsidiary (Cantwell and Mudambi, 2005).

Scholars have differentiated between various environment contexts for overseas subsidiaries, albeit in broad terms. As Forsgren et al. (2005: 183) put it: "[...] an MNC's environment consists of *several* environments, each with its own distinct characteristics." Accordingly, Andersson et al. (2002) differentiate between technical embeddedness and business embeddedness, describing technical embeddedness between firms as an interdependency between those firms in terms of technological and developmental activities (Andersson et al., 2002: 982). In this view, embeddedness is assumed to be developed over time and is treated as a strategic resource. Forsgren and Johanson (2005) contrast internal corporate and external business contexts: "This network has developed successively, together with the subsidiary's role and position within the network concerned. The different actors are connected with one another through business activities rather than [internal] administrative or legal links." (Forsgren and Johanson, 2005: 93). Forsgren et al. (2005) highlight the inter-linkage between networks, a corporate one and an external one; the latter network being the sum of a focal subsidiary's local networks and is seen as critical since it bridges the external and corporate networks. Garcia-Pont et al. (2009) have recently extended this and developed the notion of internal subsidiary embeddedness, arguing that the distinctiveness of a subsidiary (itself a key component of subsidiary strategy) is dependent on its embedment within the MNC at strategic, capability and operational levels.

Ghoshal and Bartlett's (1990) seminal work views the MNC as an "inter-organizational network", able to transfer knowledge across its dispersed but interconnected network. This network view emphasizes the subsidiary as a distinct organizational unit with its own relationships with its own external actors. Gaining access to local knowledge depends on the subsidiary's embeddedness in the host country environment, consisting of external networks, relationships to local customers, suppliers, competitors and research institutions. These various actors enable and encourage the subsidiary to upgrade products and technologies, providing impetus to new product development (Zanfei, 2000). This external network view has been a central motive for the growing interest in the asset-acquiring motive for FDI (eg. Dunning and Narula, 1995). Studies have also re-assessed the role foreign subsidiaries play, combining knowledge based and the network based views, leading to a more complex organizational network view. Subsidiaries are seen to be able to create a interface between local knowledge (resources and conditions) and company's internal business network in order to enhance knowledge creation/ development (e.g. Birkinshaw 1996, Sölvell and Birkinshaw 2000).

2.1 Review of subsidiary embedment operationalization

The presence of various contexts in which a subsidiary interacts in order to access and share knowledge and resources highlights a potential difficulty in analyzing the determinants of embedment and its consequences for performance. This is conspicuous when examining the operationalization used by scholars for measuring external embedment. Schmid and Daub (2006), in an extensive review, showed how various definitions, operationalization and measures of embeddedness have been used. Schmid and Daub (2006) also show how prior scholars have distinguished between intra, inter and local embeddedness. We build on this analysis and provide an alternative summary of operationalization used in twenty-two

empirical articles² within the literature on subsidiary embedment. Our findings are shown in Table 1.

*** Table 1 ***

In order to demonstrate the breadth of this literature, we include recent works on both R&D and non-R&D subsidiaries, as well as works treating external embedment as a dependent variable and as an independent variable (in some studies embedment has been used as both). In this summary 13 out of the 22 articles have a specific R&D focus, 8 use external embedment as a dependent variable, but only 5 have differentiated the external actors in data collection, analysis and presentation of results. The emphasis on differentiating between various types of actors appears to more prevalent in the studies that focus on R&D subsidiaries (4 out of 13 articles) compared to those focussing on subsidiaries in general (1 out of 9 articles). This is summarized in Figure 1.

*** Figure 1 ***

Two insights emerge from this overview. Firstly, there is a large variation in the operationalization of the embedment construct. Whilst some focus on frequency of communication (e.g., Nobel and Birkinshaw, 1998; Williams and Nones, 2009), others focus on depth of integration captured in various ways, including adaptation to local actors' needs (e.g., Andersson and Forsgren, 1996; Andersson and Forsgren, 2000), exchanging product or technology with actors in the local environment (Fang et al., 2002), ease of identifying and locating key resources (e.g., Cummings and Teng, 2003), and influence of external actors on

² We selected articles by means of key word search in high ranking journals on international business and management from 1996 up to 2009.

capability development within the focal subsidiary (Schmid and Schurig, 2003). Few consider direction of communication, depth of social interaction, reasons for instigating interaction, or changes in interaction over time. Secondly, there has been scant attention to the nature of differences between external actors. There is little emphasis on the external actors that are local compared to those that are regional or global organizations in their own right, or are at least located outside of both host and home country. Some have acknowledged differences between external actors (e.g., Nobel and Birkinshaw, 1998; Fang et al, 2002; Ambos, 2005; Williams and Nones, 2009) although not consistently, that is, in terms of the types of actors involved. Fang et al. (2002), for instance, include conference participation, an external activity omitted by other scholars.

By and large, scholars have tended to treat external actors in general terms, as a cohort, and focusing on how a subsidiary interacts with a group of external actors (e.g., “drawing on ideas for technological innovation *from the host country*” – Frost, 2001; “*overall external technical embeddedness*” – Anderson et al., 2001; being a “listening post” – Mudambi and Navarra, 2004; “Mutual adaption in product development and production development in the *subsidiary’s external relationships*” – Forsgren and Johanson, 2005) (emphasis added). This runs against the view that external embeddedness is multi-faceted and requires attention to the differences between actors (Anderson and Forsgren, 2000; Schmid and Schurig, 2003; Ambos, 2005; Williams and Nones, 2009).

2.2 Implications for study of R&D subsidiary embedment

These findings represent a weakness: the variance in operationalization and lack of attention to differences between external actors within the subsidiary embedment literature makes it difficult to assess the contribution to our understanding of the internationalization of R&D. Arguably, knowledge seeking, development and application by an R&D subsidiary

does not take place by being uniformly inter-connected with a set of external actors. Indeed, as Granovetter (1992) argued, all economic life has a structural dimension: the antithesis to a high degree of embeddedness is arm's-length market exchange. International R&D does not represent a trivial structure by any measure.

Firstly, it is important to recognize that there are different types of R&D subsidiaries (e.g., 'pure' R&D subsidiaries, subsidiaries with late-stage development and support activities etc.) performing different functions. The U.S. National Science Foundation (2008) categorizes R&D on a continuum ranging from basic research (i.e., earlier-stage, more exploratory, highly uncertain) to late-stage development (more applied, much less uncertain). The nature of the specific R&D will impact the pattern of external interdependence. Secondly, differences between countries' institutional contexts and national systems of innovation may determine the selection of actors and differences in depth of embedment for an R&D subsidiary. Comparative studies have highlighted the complex nature of interdependence within global innovation systems from a technological cooperation perspective (Bartholomew, 1997) and emphasized the role of country-specific agencies as knowledge-integrators (Collinson and Gregson, 2003). In this sense, the level of entrepreneurial economy - deregulation, decentralization, private ownership and knowledge-based activity (Archibugi and Iammarino, 2002; Audrestch and Thurik, 2001) - in which the R&D subsidiary resides will matter. This extends to the role of universities as entrepreneurial platforms (Etzkowitz et al., 2000). These interdependencies will differ from country to country. In addition, scholars have highlighted variation in innovation across cultures (Thomas and Mueller, 2000).

Thirdly, factors above and below country level matter to the structure of international R&D and the pattern of interconnections that an R&D subsidiary will develop over time. At sub-national level, scholars have highlighted the influence of sub-national institutional factors (Parker and Tamaschke, 2005). At regional level, scholars have described how regional

economic integration can encourage countries to work together to overcome “fragmentation and compartmentalization” within technology research (Lawton-Smith, 2007). Thus the integration of the innovation process amongst different types of actors, (including universities, private firms, government bodies, venture capitalists) is key to performance in R&D. This requires a particular recognition by the R&D subsidiary that different actors (sub-national, national, regional) will matter in different ways and that an ‘overall’ level of external embedment is neither the main purpose of the subsidiary or predictor of its performance.

3. RESOURCE DEPENDENCY AND R&D SUBSIDIARY EMBEDMENT

3.1 Overview of resource dependency theory

Resource dependence theory (Pfeffer and Salancik, 1978) can be usefully applied to the R&D subsidiary of the MNC to show how embedment of the R&D subsidiary should be treated as a more multi-faceted and complex phenomenon than has been apparent to date. According to this theory, the concepts that matter most to the external configuration of the organization (in our case, the overseas R&D subsidiary) include external drivers of organizational effectiveness, relevant events and information flows that arise unpredictably within the environment of the subsidiary, and the constraints on individual and unit behaviour that are defined by the environment (Pfeffer and Salancik, 1978). Furthermore, enactment and the way information from the environment is selected (Weick, 1969) plays a pivotal role. This theory takes on extra importance in the case of an R&D subsidiary as the specific nature of the R&D activity will determine the extent to which the unit is controlled by actors that influence more exploratory, basic research, as opposed to late-stage applied research (U.S. National Science Foundation, 2008)

According to resource dependency theory, managers choose from their environment „what will be important... [selecting] what will be the relevant operating context for them“

(Astley and Van de Ven, 1983: 253). In so doing managers seek to increase their bargaining power vis-a-vis external actors in the environment that are suppliers of critical resources. Ineffective bargaining power may result in actors in the external environment withholding critical resources and the organization's ability to obtain resources from the environment is a principal determinant of its effectiveness (Aldrich, 1979).

Resource dependency theory pays particular attention to the task environment of the organization. Scholars have described this task environment as being complex and multi-dimensional. Dess and Beard (1984) classified task environments along three dimensions: munificence (capacity), complexity (homogeneity-heterogeneity, concentration-dispersion) and dynamism (stability-instability, turbulence). This built on (condensed) Aldrich's (1979) identification of six dimensions of organizational environments. Capacity relates to the level of resource availability; homogeneity-heterogeneity refers to the extent to which resources and actors in the environment are similar; stability is a measure of turnover of environmental elements; concentration refers to the distribution of resources within the environment; consensus relates to disputes amongst organizations regarding the focal organization's claim to a domain of resources; turbulence is defined as the interconnectedness amongst resource elements in the environment (Aldrich, 1979; Boyd, 1990)

The external environment can be manipulated by the organization (through political mechanisms) to achieve the objectives of the organization's top management team (Pfeffer and Salancik, 1978; Astley and Van de Ven, 1983). Scholars in the field of inter-organizational relations have put an emphasis on political advocacy through coalitions and alliances. The focal organization's selection of coalition forms arises through incentives, including accessing and controlling essential resources (Galaskiewicz, 1985). Participation in a network of inter-dependent organizations also entails provision of resources (resource transferring) and the inevitable asymmetry of information and know-how in the resources that

are controlled by the firm (Grandori and Soda, 1995). Organizations may seek to manipulate the transactions and ‘games’ between actors in order to gain advantage from the relationship (Grandori and Soda, 1995)

3.2 Resource Dependency and the R&D Subsidiary

It is well acknowledged that MNCs develop R&D capabilities outside of their country of origin in order to seek new knowledge for product and technology development, enabling them to build and sustain competitive advantage on a global basis (Dunning & Narula 1995; Kuemmerle 1997; Santangelo 2002). More and more attention has therefore been paid to the strategic role of foreign R&D units, including the need for their embedment in networks of innovation. These centres develop critical repositories of knowledge through dependency relationships within the international systems of innovation and also have a long-term impact on the activities conducted by other corporate units. Some assume strategic roles, for example, yielding specialized competence as Centres of Excellence (CoE) (Birkinshaw & Hood, 1998; Holm & Pedersen, 2000).

However, as we have seen above, there are weaknesses in scholarly operationalization of subsidiary embedment. These weaknesses raise doubts about their usefulness to our understanding of the determinants and consequences of international R&D within MNCs. Resource dependency theory can be used to address this deficit and provide guidance for future empirical enquiry. In Table 2 we provide an overview of the central tenets of resource dependency theory as applied to the overseas R&D subsidiary of the MNC. We split the tenets into two parts: those related to the external environment and those related to organization and managerial interaction with external actors within that environment.

*** Table 2 ***

Principal arguments that focus mainly on actors within the external environment include the following: (1) *performance*: that drivers of organizational effectiveness are external; (2) *relevance*: that events and information flows that are relevant to the organization arise unpredictably in the external environment; (3) *constraints*: that the environment constrains individual and unit behaviour within the organization; and (4) *task complexity*: that the task environment is complex and multi-dimensional. Principal arguments that focus mainly on interactions between the managers of the focal organization and actors within the external environment include the following: (1) that managers select what is important from the external environment; (2) that managers seek to increase their bargaining power with actors within the external environment; and (3) that the external environment may be manipulated by the focal organization.

These groups of tenets can be applied to the R&D subsidiary of the MNC and used to develop implications for the construct of external subsidiary embedment. As shown in Table 2, the implications are wide-ranging and not trivial. In terms of focus on the external environment, RDT suggests any study of R&D subsidiary performance needs to include external embedment as key predictor. Given that R&D subsidiaries require knowledge and resources from a range of actors and events within the international systems of innovation, all types of actors need to be considered. Secondly, external embedment should not be considered static and operationalization should incorporate changes over time. These changes should capture the relevance (i.e., usefulness for the specific R&D undertaken by the subsidiary) of knowledge and resources available from the different types of actors, as well as the predictability of the knowledge and resources (i.e., degree of reliance on specified actors for specific resources). Thirdly, the external environment places constraints on the work carried out by the R&D subsidiary. These constraints may affect the R&D process – the

sequence of activities and the quality controls that are required by law at each step of the process. They will also include constraints defined by the patenting process. Constraints may also apply to the outcome, or product, of R&D activity, such as a new unit of technology, a new patent, or even a new proposal for innovative project work. This may apply to end-products as much as it does to intermediate products and even to the commercial viability of projects. Finally, RDT highlights the complexity and multi-dimensional nature of the task environment. The implications of this for R&D subsidiary embedment include paying explicit attention to the location of the external actor (the precise location within the host country as well as the host country itself) and the mandate of the external actor (e.g, municipal, local host country, regional bloc, global).

In terms of focus on the organizational and managerial interaction with the external environment, RDT suggests the following implications for the external embedment construct. Firstly, this line of reasoning puts a focus on the managers of the R&D subsidiary. Managers' assessment of knowledge and resources in the external environment will depend on their ability to identify sources and evaluate the relevance of those sources to the work conducted by the subsidiary. Thus the current state of development and mandate of the subsidiary becomes important, as does manager awareness of how important knowledge and resources are distributed. As cognitive biases differ across managers (Baron, 1998, 2004) we may expect managers to differ with respect to what is considered relevant. Therefore operationalizing the selection tenet should draw on actual decisions made. Actual decisions take into account differences of opinion and assume differences of opinion to have been overcome by the time the selection decision is made. Secondly, in terms of manager bargaining power embedment may be indicated by the degree to which managers yield power over external actors. In the case of the R&D subsidiary, this may refer to bargaining over price in the conventional sense (e.g., Porter, 1980), as well as attributes of inputs that are

critical to the field of R&D, such as quality of precision, reliability and timeliness of delivery. The focal organization may lose bargaining power if it loses proprietary knowledge. Thus bargaining power may also be indicated by effective control and protection of knowledge. Thirdly, in terms of the focal organization manipulating the environment, embedment of the R&D subsidiary may be indicated by mechanisms used by the subsidiary to change its environment. This may include attempts to establish new technological standards or change / upgrade existing standards. These institutional changes will be more profound if they require competitors to subsequently change internal processes or organization.

4. RECOMMENDATIONS FOR FUTURE RESEARCH

Following this analysis we make a number of recommendations. Firstly, we should expect the embedment construct to be formative, rather than reflective, in nature. The formative development of the embedment construct for R&D subsidiaries (Nobel and Birkinshaw, 1998: 488) stresses the importance of reporting external communication flows individually “to ensure that the subtle differences between communication patterns are brought out”. Thus the external embedment of the R&D subsidiary may be considered a useful application for a formative construct. Diamantopoulos et al. (2008) examine issues relating to conceptualization, estimation and validation of formative measurement models. Care should be taken interpreting the error term at construct – rather than individual indicator – level, dealing with multicollinearity, inter-indicator correlations, and model estimation issues, and assessing validity. Secondly, researchers should treat embedment as a multi-level construct. Our summary of empirical studies shown in Table 1 contains aspects of embedment of an overseas subsidiary with local, sub-national actors, national actors, and regional and global actors. Whilst these may be seen as distinct actors and thus treated through formative measurement, there are important conceptual differences between actors at the various levels

in terms of the nature of their relationship with a focal R&D subsidiary. These differences will impact the requirement for resource provision from the external environment and hence the frequency and depth of contact required for optimum performance. In this sense, there are important inter-relationships between the actors at various levels which may impact the nature of embedment and distribution of resource dependencies for a focal R&D subsidiary. Thirdly, researchers should run tests for (and report) different (alternative) models during empirical fieldwork, including those with ‘overall’ embedment operationalizations (e.g., a single embedment variable) vs. those split by actor or other dimension (i.e., multiple embedment variables). This will be particularly useful for scholars and practitioners to assess the interpretation of overall embedment within the framework of the study. Fourthly, researchers should work towards measuring R&D subsidiary embedment from both sides of the relationship in order to get a more accurate estimation of the depth of influence and the contingencies under which mutual influence develops. Fifthly, empirical fieldwork is needed to investigate the links between resource dependency, embedment and R&D subsidiary performance. Finally, national initiatives such as cluster policy, centres of competence initiatives etc. are of growing importance. National innovation policymakers have been setting such stimulating policy measurements from the early 1990s. A key goal of these policies has been to reap economic benefits from MNC subsidiary embedment. In this context activities of subsidiaries in the host country serve long-term development goals, not just to contribute to the MNC, but also to upgrade domestic skills, competences etc. This may be achieved by promoting backward and forward linkages with customers, suppliers, but also by promoting horizontal linkages, skills and technology development with public research institutions and universities. Indeed, even ‘new-economy’ countries such as China have recognized these potential environmental and social implications of “embedding” foreign, knowledge intensive subsidiaries, and therefore they promote public funding for foreign

companies in the case they are engaged in R&D, and present local linkages. Thus, embedment is seen a major determinant in innovation policy (particularly important for the distribution of public subsidies in the business sector). Researchers should therefore think more deeply about how the operationalization of embedment – as well as the results of studies using different operationalizations - can best serve as reliable policy instruments.

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FIGURES

Figure 1. Summary of external subsidiary embedment approaches in 22 selected studies

Differentiated actors	1 article	4 articles
No / weak differentiation of actors	8 articles	9 articles
	Non-R&D Focus	R&D Focus

TABLES

Table 1. Operationalization of external subsidiary embedment in selected empirical studies

Authors	Main angle / RQ	R&D focus?	Operationalization of embedment	Embedment as IV / DV	Differentiated external actors?
Ambos (2005)	International investments of German MNCs	Yes	External ties measured through 'intensity of ties' with seven local actors: competitors, suppliers, customers, other firms, private research institutes, universities, local authorities + a total external embeddedness scale	DV	Yes
Ambos and Schlegelmilch (2004)	Use of teams in international R&D networks	Yes	Capability augmentation at subsidiary level: "experimental or theoretical work undertaken to create or acquire new knowledge that your firm considers important for future products" + variables for global and regional market mandates	IV	No
Andersson and Forsgren (1996)	Subsidiary embeddedness link to external actor influence over subsidiary behaviour (perceived control)	No	Subsidiary's technological embeddedness ³ : subsidiary adaptation of its product and production technology to its three most important customers, suppliers and other actors	IV	Partial
Andersson and Forsgren (2000)	External embeddedness as a determinant of subsidiary importance and influence	No	Three most important relationships to customers and suppliers: technological embeddedness – subsidiary adaptation to product and production technology	IV	No
Andersson, Forsgren and Pedersen (2001)	Link between subsidiary technological embeddedness and performance	No	Subsidiary's technological embeddedness: degree to which the subsidiary adapts to its customers/suppliers, and the importance of a given customer/supplier relationship to product and production development	IV	No
Andersson, Forsgren and Holm (2002)	Impact of subsidiary technical and business embeddedness on: (1) subsidiary importance for competence development and (2) subsidiary market	No	Business embeddedness: adaption to ways of doing business with most important customers and suppliers (not specified); number of functional areas involved in direct contact with customers and suppliers (not specified)	IV	Partial (averaged over a number of external relationships identified)

³ Authors include a discussion on difficulty of operationalizing the concept of embeddedness (p. 497)

Authors	Main angle / RQ	R&D focus?	Operationalization of embedment	Embedment as IV / DV	Differentiated external actors?
	performance		Technical embeddedness: adaption to product and production development caused through relationship with a specific external counterpart (not specified)		
Andersson, Björkman and Forsgren (2005)	Factors affecting local embeddedness	No	Adaptation to product and production technology, standard operating procedures and best practice as a result of the most important external business relationships	DV / Intermediate variable	Partial / (not specified)
Belderbos (2001)	Volume of innovation (patent grants) by Japanese firms	Yes	Indirectly through extent of overseas acquisitions of manufacturing as a way of accessing international R&D resources	IV	No
Cantwell and Mudambi (2005)	Level of R&D in MNC subsidiaries (competence-creating vs. competence-exploiting)	Yes	Indirectly linked through subsidiary strategic independence (autonomy): local supplier decisions, local hiring decisions, local marketing decisions, extent of local top management team	IV	No
Cummings and Teng (2003)	Knowledge transfer success in intra- and inter-firm relationships	Yes	Ease of identifying personnel, tools from external environment; ease of locating and extracting information from external environment	IV	No
Fang et al (2002)	R&D programs and facilities of foreign firms in Taiwan – impact on knowledge flow in Taiwan	Yes	Host country knowledge flow interface: 4 factors derived through factor analysis: contracting-out research, technology exchange equipment sale, HR exchange product sale, conference transference	DV	Yes
Foss and Pedersen (2002)	Determinants of knowledge transfer within MNCs	No	Network knowledge: impact of various external organizations (external market customers and suppliers, specific distributor and external R&D unit) on development of focal subsidiary competences	IV	Partial (Network knowledge averaged)
Frost (2001)	Innovative output of subsidiaries and sources of knowledge (home country /	Yes	A cluster knowledge IV is also used. However, this relates to availability and quality of external actors rather than capturing any sense of embedment. Technological ideas originating in the host country: patent citation originating in host country or subsidiary's host state	DV	No

Authors	Main angle / RQ	R&D focus?	Operationalization of embedment	Embedment as IV / DV	Differentiated external actors?
Grandstand (1999)	Internationalization of R&D: growth, pace, demand / supply factors, university collaborations host country)	Yes	Supply side factors: access to foreign S&T, access to foreign R&D personnel	IV	No
Håkanson and Nobel (2001)	Embeddedness and integration of the subsidiary as determinants of technology transfer from subsidiary to parent	Yes	Frequency of various types of contacts / number of ongoing cooperative projects with local universities and research institutions, customers (local) and suppliers (local)	DV / IV	No
Isawa and Odagiri (2004)	Patent performance of Japanese MNCs in US and Japan	Yes	Indirectly through indices for local technological strength: spillovers of patenting by host country geography (US state) and technological field (industry)	IV	No
Li (2005)	Relationship between trust and shared vision and inward knowledge transfer into the subsidiary	No	Extent to which knowledge has been transferred into the subsidiary over a 3 year period in 5 business areas (DV) / combined with a dummy variable (IV) indicating the type of relationship (internal headquarter vs external firms (n=51))	DV / IV	No
Manolopoulos et al. (2005)	Relationship between sources of technology and differentiation in type of subsidiaries	Yes	R&D carried out in collaboration with another local firm, local scientific institutions	DV	Partial (local firms and local scientific institutions)
Newbury (2001)	Explaining perceptions of career benefits arising from global integration	No	Shared client communication: frequency with three main clients + % shared with other units	IV	No
Nobel and Birkinshaw (1998)	Control and communication in overseas R&D subsidiaries of different types / mandate	Yes	External communication (frequency of contacts) (various types: face-to-face, letter, phone, digital) with universities, customers and suppliers in the local, Swedish and international domains	IV	Yes
Schmid and Schurig (2003)	The role of internal and external actors for capability	No	Degree of influence that external partner has on the development of capabilities in the subsidiary	IV	Yes

Authors	Main angle / RQ	R&D focus?	Operationalization of embedment	Embedment as IV / DV	Differentiated external actors?
Williams and Nones (2009)	development in the subsidiary Determinants of isolation of R&D subsidiaries in Austria	Yes	Frequency of communication between subsidiary and 4 types of local actors: customers, suppliers, competitors, research institutions / universities	DV	Yes

Table 2. Resource dependency theory and improving the operationalization of R&D subsidiary embedment

Focus of analysis	Tenet and principal argument	Application to the R&D subsidiary	Implications for the external embedment construct
External environment	Drivers of organizational effectiveness are external	Patent performance depends on a variety of actors and events within the external network of innovation: governments, universities, research labs, customers, partner firms (including SMEs and units of other MNCs), suppliers, conferences.	Studies of R&D subsidiary performance should use external embedment as an independent variable.
	Relevant events and information flows arise unpredictably within the environment	It is not possible to foresee with certainty which external actors provide knowledge and resources most relevant for subsidiary innovation – this relevance may change over time and what is considered relevant will depend on the nature of R&D undertaken in the subsidiary (early-stage basic research through to later-stage applied activities) and the status of specific projects and activities.	All actors within the network of innovation need to be captured.
	Constraints on individual and unit behaviour are defined by the environment	External institutions define the process of R&D, including quality and product testing standards, technical feasibility; commercial institutions determining commercial viability and choice of research projects.	External embedment should not be considered static. Measurements should capture interactions between the R&D subsidiary and the external actors over a sufficient period of time. Measurements should capture the nature of predictability of interaction and useful knowledge and resource flow across actors. External embedment should incorporate the influence that external actors have on the R&D process. Measurements should distinguish between actors that constrain product and process development with those that constrain commercial viability.

Focus of analysis	Tenet and principal argument	Application to the R&D subsidiary	Implications for the external embedment construct
	The task environment being complex and multi-dimensional	Due to the internationalization of R&D, the external actors can be local, regional or global organizations; some are located locally, some outside both host and home country.	Location of external actor should not be constrained to the host country. Scope / mandate of external actor should not be constrained to the host country.
The interaction of the organization / managers with the environment	Selecting what is important from the environment	Required assets (explicit and tacit knowledge flows from the various external actors, components and intermediate products; tools and scientific equipment) will depend on need (state of development of the unit) and availability. Providers of knowledge and resources (location, type of actor, specific actor) likely change over time as subsidiary develops, host country develops and shifts in the internationalization of R&D occur.	A focus must also be placed on the managers of the R&D subsidiary: their assessment of what external knowledge and resources are relevant given the state of development of the subsidiary, the technological development of the host country, and overall shifts in the internationalization of R&D. Managers may differ in their opinion of what knowledge and resources are relevant, therefore necessary to capture actual decisions made.
	Managers seeking to increase their bargaining power	R&D managers seeking cost reduction on more stable / mature technologies, attempts to reduce supplier power; Managers attempts to limit IPR infringement or knowledge leakage to external partners; Industry-specific influence, such as relationships with key opinion leaders in pharmaceuticals.	The degree to which managers of the subsidiary develop and yield power over different external actors should be captured. This should extend beyond influence over supplier price and include quality and timeliness of inputs. Control over knowledge (an important source of bargaining power) should be captured, as well as bargaining with actors specific to the industry.
	External environment being manipulated by the organization	Top management team of the R&D subsidiary building relational capital with the various actors, including participation in (and leading) newly emerging institutions such as those setting standards for new technologies and the actual standards (e.g., case of Sun and JAVA).	It is necessary to consider ways in which the R&D subsidiary is able to change its environment, including setting up – or making changes to – institutions and standards that affect other actors (e.g., competitors).

