# 9. THE ROLE OF INDIGENOUS FIRMS IN INNOVATION SYSTEMS IN DEVELOPING COUNTRIES

## The developmental implications of national champion firms´ response to underdeveloped national innovation systems

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### 9.1 Introduction

This chapter discusses the role of national champion firms in supporting the development of domestic capabilities and thus the national innovation system. A number of role-players are repeatedly mentioned in studies of innovation systems in developing countries, including the research, education and training infrastructure,

MNCs and local suppliers, and financial markets and labour market arrangements (Bell and Pavitt, 1992, Dosi, Pavitt, and Soete, 1990, Ernst, 2002, Lall, 2001b, Mowery and Nelson, 1999). But in spite of the importance of national champion firms in less developed countries, little is understood about how they interact with their national innovation system. This research attempts to fill that gap by investigating the interaction between the champion firm and its institutional context.

The creation of national champion firms is one of the stereotypical forms of government intervention in developing countries (Lall and Teubal, 2001). Whether they be South Korean chaebols, Chinese state-owned enterprises, or Brazilian firms like CVRD, Embraer and Petrobras, there is no shortage of examples of firms that receive considerable state support with the expectation that they will contribute to a sector that is deemed strategic by government.

Various studies examine the capability evolution of firms such as Embraer (Bernard and Oliviera, 2003), Hyundai (Kim, 1998) and Samsung (Lee, 2001). A further number of studies hone in on how (elements of) innovation systems contribute to the capability development of developing country firms (Dantas and Bell, 2006, Figueiredo, 2008, Hobday, 2000). The increasing prominence of multinationals from the developing world (e.g. Sauvant, 2008) suggests that a fair number of those firms succeed in becoming globally competitive. But the effectiveness of an emphasis on national champion firms as a general development strategy is unclear. For example, Teubal (1996) argues that in initial phases of development, industrial policy should be neutral, i.e. not privilege specific firms or sectors, in order to develop as wide a capability base as possible. At the same time, Murmann (2003) provides compelling evidence of the co-evolution of firms, technology and national institutions, suggesting

that it is in principle possible for leading firms to create momentum that drives upgrading in the country in general.

Marin and Arza (chapter 10 in this volume) document the role that MNC subsidiaries can play as a connector between global knowledge networks and the national system of innovation. To the extent that champion firms – typically larger firms with international linkages and thus the potential to connect with the relevant global networks – can be assumed to be embedded in their local environment, they are also well suited to play such a connector role. This chapter critically examines the extent to which national champion firms contribute to the national innovation system, and finds that the logic from Marin and Arza holds – champion firms can act as enabling brokers between the global and the local. However, we document that champion firms do not always facilitate such co-evolution between the firm and its underdeveloped context. Champion firms can also act as enclaves within their own countries, primarily drawing on (and contributing to) foreign expertise, or they can alternatively internalise activities to the extent that the national innovation system reaps very few benefits from the capability expansion of the champion firm.

This chapter investigates the role of the South African Coal, Oil and Gas Corporation (Sasol), a national champion firm, in the evolution of the national innovation system of South Africa. Sasol was founded in 1950 by the National Party government in order to ensure greater fuel self-sufficiency for South Africa. Before its first decade had passed, its director expressed the belief that Sasol had an important role to play not only in the production of fuels and chemicals, but also in the upliftment of the country as a whole (Sasol, 1958: 1007)[1]. We find that the contribution of a national champion firm like Sasol to the national innovation system is fundamentally (de)limited by the institutional

framework within which the firm finds itself. The birth of Sasol in 1950 was a direct result of the rise to power of the Apartheid government in 1948, and the evolution of the firm has clearly been shaped – positively and negatively – by government policies. National champion firms are shaped by the formal and informal constraints defining their home environment.

There is less evidence of the reverse – the ability of Sasol to shape either the institutions (e.g. government policies) or the firms operating in South Africa. Although it has played an important role in upgrading the scientific capabilities in the country, the contribution of Sasol to the innovative capabilities of the country has been limited by not only the scientifically underdeveloped, but more importantly, also by the politically problematic innovation system within which the firm found itself.

This study draws on the taxonomy presented by Hollingsworth (2000) to analyse the interaction between Sasol and its environment. Hollingsworth argues that institutional arrangements can be conceptualised along two dimensions, the action motive (self-interest or social obligation) and the distribution of power (through markets or hierarchies). Because champion firms are often quite directly seen as agents of the state, they have to deal with social obligation, but they are also self-interested entities operating in a market place. Similarly, they have to deal with both the state apparatus (i.e. hierarchy) and other firms, e.g. their suppliers and competitors, and thus a market-based distribution of power. By documenting how Sasol has over the first 50 years of its existence navigated those tensions in its underdeveloped context, this study develops three models of how a champion firm in a developing country can interact with its innovation system: co-evolution, internalisation and global enclave formation.

The ideal is co-evolution, where the firm is in productive dialogue with the range of other partners in its local innovation system. In the cases where Sasol did achieve such dialogue, Sasol's expertise also proved of benefit to other innovation parties in South Africa. Where co-evolution does not take place, champion firms can use two other strategies. With internalisation, the firm assumes responsibility for activities that would otherwise be provided by other actors in the local innovation system (e.g. in the case of the conglomerates identified by Khanna and Palepu, 1997). Alternatively, firms can form enclaves by limiting interaction with weaker local institutions, and drawing most of their resources from abroad. The Sasol case also provides examples of these other two mechanisms, and of how they have a limiting effect on the upgrading of the national innovation system.

The chapter is organized as follows. After this introductory part, the section 9.2 covers literature discussing the main ways in which a leading firm can interact with its innovation system, the mutual relationship between the firm and institutional arrangements in the innovation system and the implications of those interactions for the evolution of its innovation system. The section 9.3 introduces a concrete case of a national champion firm in South Africa. The section 9.4 describes the models of interaction between the national champion firm and the national innovation system in South Africa. The last section concludes.

**Box 9.1 The role of Indigenous firms in innovation systems in developing countries: main terms used in this chapter**

*Indigenous firms* = are those firms operating in their home country. The home country is typically the country where the bulk of the firm's sales and its management team are from, and where the firm is registered and listed.

*(National) champion firms* = are indigenous firms, typically in developing countries, that receive considerable state support in order for them to fulfil a state mandate, e.g. security or energy sufficiency.

Hollingsworth defines *institutional arrangements* as the different economic entities that exist to coordinate activities in an economy, including markets, states, corporations etc.

Not all institutional arrangements have an equal *power distribution***,** i.e. ability to act effectively**.** If the power distribution is uneven and interaction is structured between leaders and followers, it is considered a *hierarchy*. In a *market*, there is a greater degree of equality between actors.

The *action motive* = is the primary reason why entities will undertake certain actions., and is divided into two main categories, *social obligation* where entities will seek to meet the often diverse needs of a group, or *self-interest*, where entities' specific needs are foremost.

Co-evolution = takes place when multiple elements develop at the same time, and through their interactions with each other.

*Internalisation* = takes place when a firm develops the capacity to meet its needs on its own, rather than by interacting with the external environment (e.g. get equipment from suppliers or qualified people from the state university).

An *enclave* is enclosed by a larger unit, but is not part of it. A *global enclave* is used to refer to a unit that is geographically situated in a less developed country, but is connected globally rather than to its own country.

## 9.2. Innovation systems and the role of champion firms – a review of the literature

The innovation systems literature has focused mainly on the role of the system supporting upgrading and innovation in local firms, as well as on the role of MNCs' spillovers to local firms. Hitherto, little attention has been paid to the role of indigenous firms (champion firms) supporting capacity building in the local or national innovation system. This study addresses this gap by investigating the interaction between the champion firm and its institutional context.

The literature review focuses on first national innovation systems, particularly in developing countries. We then discuss the tensions introduced by the almost contradictory expectations of champion firms in their institutional context. Champion firms need to reconcile an expectation that they will act both out of social obligation (as national institution) and self-interest (as profit-making entity), and are best able to contribute to the national innovation system when those expectations are in alignment. In terms of the distribution of power, champion firms have access on a relatively equal basis to international markets where they can source sophisticated goods. At the same

time, they have to maintain a critical relationship with the state hierarchy, even though it is virtually axiomatic that the state apparatus in developing countries does not function optimally. We propose that champion firms can respond in three main ways to those tensions, and discuss those ways in which a leading firm can interact with its innovation system and the implications of those interactions for the evolution of the system.

### 9.2.1. The systemic and evolutionary nature of innovation

The most illuminating research on the relationship between firms and their environments has emphasised the systemic nature of that relationship – how different elements work in a systemic way to enable (or hinder) innovation (Lundvall, 2004, Nelson, 1992). A number of historical examples document the role of that interaction in effecting change: At the level of basic infrastructure, the growth of capital-intensive industries in the US had to wait until the transportation and communication infrastructure (e.g. steamship, rail, and telegraph) could ensure the steady flow of materials into and out of manufacturing establishments (Chandler, 1997). Murmann (2003) details for Germany, the UK and US the co-evolution of the chemical industry and national institutions like patenting laws and the university system. A Danish study documents how institutions as diverse as the labour market (a combination of low legal job security and significant unemployment assistance), and the education system, which tends to under-emphasise formal achievement, shape the nature of the innovative process in Denmark (Lundvall, 2002).

In developing countries, the same elements are found. Thus Lall (2001d) highlights the importance of the training and education infrastructure, financial markets, and

technological support structures. But various studies highlight important differences in how those elements function. In their study of the Bangalore IT industry, Vang, Chaminade, and Coenen (forthcoming) find that firms' needs from universities differ depending on whether firms are essentially local specialists (where the greatest need is for universities to provide skilled employees) or whether they are aspiring to become world-class players (where they require more direct interaction and knowledge creation from universities). In their study of Petrobras in Brazil, Dantas and Bell (2006) document that not only the different elements, but also the linkages between them are the result of a cumulative, evolutionary process. This suggests that the nature of the relationship between a leading firm (such as either Petrobras or Sasol) and other components in the innovation system of a developing country will change over time, and that a major driver in the change will be the accumulated capabilities of the lead firm.

Various studies of leading firms in the developing world, e.g. Hobday (1995b), Kim (1998), Lautier (2001), Lee (2000, 2001) and Perrin (2001) on South Korea and Dutrénit (2006) and Figueiredo (2003, 2008) on Latin America document how particular firms have developed capabilities. It is striking that many of the newly-prominent multinationals from the developing world have at some point benefited from preferential treatment in their home countries. Developing countries often focus their efforts on "national champions", leading firms that receive a high level of government support, because broad-based development is so resource intensive and time-consuming.

The preferred access to resources and opportunities does mitigate some of the challenges of operating in underdeveloped environments, and has played an important

role in the rise of new multinational corporations such as Hyundai and Samsung. What has not been as extensively studied, is whether and how the reverse process takes place: How leading firms from developing countries shape – or not – the national innovation systems from which they hail.

If the goal is general development, providing preferential resources to specific firms may not be the best strategy: Dodgson (2000) makes the point that targeted intervention may create a situation where the capabilities of the leading firms are too far ahead those of local firms to lead to meaningful spillovers to the local economy. Both Chaminade and Vang (2006) and Teubal (1996) argue that because change needs to be systemic, isolated interventions are unlikely to be effective. Even at the firm-level, a targeted intervention strategy has to be questioned: Sachwald (2001) documents that the South Korean chaebols' privileged status prevented them from discovering their relative lack of competitiveness until they internationalised. On the other hand, evidence suggests that less developed countries increasingly enter the global economy with more narrowly focused technological specialisations than before (Cantwell and Vertova, 2004). To the extent that a national champion firm spearheads the development of an important niche technology in its country, for example in the case of Samsung and the semi-conductor industry in South Korea, there can be a close correspondence between the upgrading of the innovative capabilities of the firm, and the innovative capabilities of its country.

### 9.2.2. Institutions and the action motive

In order to understand the potential for a mutually (rather than unilaterally) enabling relationship between leading firms and their innovation systems, it is important to

consider institutions. North (1990) argues that institutions create incentive systems that shape human interaction within the limitations of boundedly rational and political processes, and that organisations emerge to pursue the particular opportunities created by specific institutional frameworks. In this sense, North regards institutions literally as "the rules of the game". Hollingsworth (2000) extends the work of North and maps the institutional components into different levels of analysis. He agrees with North that the norms and conventions of a society provide the most lasting and fundamental organising framework for behaviour, and then identifies the increasingly specific and changeable components that give expression to those rules. Markets, states and corporations operate at the second level of analysis, and "regularly engage in contests to resolve various economic problems" (2000:605) as they translate the unwritten rules of the game into institutional arrangements. In other words, this level, which is the level at which champion firms engage with markets and their state, is characterised by contestation as much as by coordination. Hollingsworth identifies two dimensions shaping the process of coordination and contestation: The motive for action, and the distribution of power.

The motive for action can be either self-interest or social obligation. Hollingsworth (2000) makes the point that economic activity is typically conceptualised as self-interested, and not informed by notions of trust, reciprocity or obligation, even though an excessive market focus may lead to "ruinous competition". Champion firms with their social mandate quite clearly do not fall into that narrow categorisation. But especially where they operate in an open market (as Sasol, Embraer or Hyundai have had to do) champion firms must contend with competitors that are much less constrained by social obligation. Champion firms must therefore find a way to respond to the pressures of self-interested competitors while meeting their social obligations.

How firms respond to those pressures are presented in the three frameworks for how champion firms engage with the innovation system (see Section 9.2.5).

### 9.2.3. The distribution of power in the national innovation system

Power is equally central to understanding institutions. Hollingsworth (2000) regards the distribution of power (via more equitable markets or less equitable hierarchies) as one of the core dimensions according to which institutional arrangements are structured. North puts it even more directly:

> Institutions are not necessarily or even usually created to be socially efficient; rather they, or at least the formal rules, are created to serve the interests of those with the bargaining power to create new rules. (North, 1997)

Champion firms enter into hierarchies with some such power. For example, in their study of value chains Pietrobelli and Rabellotti (chapter 8 in this volume) point out how often indigenous firms from developing countries are low power actors in global value chains. In contrast, champion firms tend to be lead firms within their (admittedly less global) value chains.

However, the most important stakeholder for champion firms is the state, and no entity has more bargaining power than the state. Not only does the state exert control over the definition of formal rules (amongst other through the setting of formal policy), but it is also the enforcer of those rules. It can even choose to engage directly in economic activity. Its power is not dependent on its competence – the state has the power to set policy or enforce rules whether it does so competently or not. This means that even a weak state is more powerful than a competent champion firm. For example, champion

firms in developing countries are typically also recipients of government largesse, which constrains their ability to challenge government.

Where there are failures in the government infrastructure or policies, firms may choose to engage directly with government to change policies. However, given the difference in power, champion firms may well decide not to challenge the state hierarchy about comprehensive economic reform and upgrading, but rather to seek individualised preferential treatment for themselves. In other words, although national champion firms could in principle facilitate the co-evolution of their capabilities and the capabilities of the broader innovation system, they may in practice struggle to engage in productive dialogue with the state. In such a case, a strategy of internalisation may well be the most appropriate response.

### 9.2.4. Market elements in the national innovation system

An alternative mechanism for gaining access to resources is through markets. The presence of market elements (e.g. competitors, suppliers and demand factors) as well as hierarchies (e.g. government agencies and educational institutions) is one of the persistent commonalities among the number of typologies that have emerged to capture different dimensions of systems of innovation (e.g. Doloreux, 2002, Meeus and Edquist, 2006). Markets have been documented as playing an important role in innovation, as firms innovate by integrating the possibilities of markets with emerging technologies (Cantwell and Fai, 1999).

In practice, the "market" and "hierarchy" distinction is an oversimplification. Thus in order to strengthen what is typically regarded as an element of the state hierarchy, the

education system, Sasol has in the recent era provided direct (and extensive) financial support for universities. Similarly, a number of aspects that are considered under the "market" heading (e.g. alliances) also have to do with firm-level competence building and the forging of intra-organizational governance mechanisms. In fact, Cantwell and Fai (1999) argue that the firm (through, in the terminology of Nelson and Winter, 1982, its established organisational routines) provides a mechanism for stability in technological trajectories amidst more radical change and transformation in its external environment. This is particularly consequential in a developing country context, where the goal is to effect more rather than less dramatic change.

However, because power in markets is more equitably distributed than in hierarchies, markets provide reasonably accessible sources of new capabilities. For example, compared to the hierarchical interaction with the state, market-based interaction offers champion firms a greater degree of freedom in how they meet their resource needs. Figure 9.1 (an adaptation of the Meeus and Edquist 2006 model) highlights important market elements that contribute to innovation.

[Figure 9.1 about here]

One of the market elements determining the attractiveness of a given location is the level and sophistication of demand. Since Schmookler's study (1962) of patenting activity in the US railroad industry, there has been recognition that invention takes place in respond to economic demand. Rosenberg's work on the machine tool industry in the US (1976) highlights the role of industrial customers in the initial development of textile and other machinery, and of expanding final customer markets in the increasing

specialisation of tools. A study of why Germany became leaders in chemicals and electrical machinery points to the absence of a large consumer base that led firms to concentrate on industrial customers (Dornseifer, 1995). In all the cases, a sophisticated consumer demands a better product, forcing the firm to improve its offering or lose the customer. In certain instances, customers – termed "lead users" by Von Hippel (1986) – even become sources of innovation themselves.

Because demand issues are of greatest relevance at a macro level, it is important to consider whether a developing country is closed (such as the Latin American countries in the 1970s) or open, where the role of generally less sophisticated domestic demand is surpassed by the drive to tap into high income export markets (e.g. China in the 1990s). In the case of South Africa, the initial election of the National Party in 1948 ushered in an era of mild isolationism under the rubric of self-reliance. As international resistance to the party's Apartheid policies grew, economic sanctions and an academic boycott increasingly served to isolate the country. The isolation intensified until 1990, when the release of Nelson Mandela marked the end of Apartheid and the re-entry of South Africa to the global economy. It is therefore important to consider how the changing role of openness and trade has transformed the relationship between demand and upgrading.

Yet demand factors can play a role only once technological know-how is available to translate demand into an economically feasible innovation (Mowery and Rosenberg, 1982). In an era of increasing technological diversification and global competition, such key knowledge is almost never embedded solely in the firm, but instead is distributed both geographically and across a number of different relationships (Granstrand and Sjölander, 1990, Patel and Pavitt, 1998).

Because key knowledge is often also embedded in the routines of a range of other actors, the presence of such actors is another important determinant of the attractiveness of a location. Suppliers are one such source of innovation, as often noted by analysts of the Japanese auto industry (Dyer, 1996, Florida and Kenny, 2000, Wasti and Liker, 1997). In addition to formal co-development arrangements, there can also be an informal process of learning and feedback between firms and their suppliers. In both cases, the more competent the supplier, the greater is the possibility of learning.

A similar source of innovation is relationships with rival firms. This can take numerous forms, ranging from competitive pressures that spur innovation by rivals, to imitation of the superior practices of other firms. Innovation is aided by both informal knowledge trading (Schrader, 1991, Von Hippel, 1987) and by formal alliances (e.g. Glaister and Buckley, 1996, Mowery, Oxley, and Silverman, 1998, Simonin, 1999), while workers who circulate between firms also support the cross-pollination of ideas across the industry (Almeida and Kogut, 1999, Saxenian, 1994, Song, Almeida, and Wu, 2003). In short, locations benefit from the presence of a range of strong firms, whether as suppliers, competitors or industrial customers.

Much as market factors can play an important role in innovation and learning, they function better the more sophisticated the general market environment. Because markets and market elements in developing countries tend to be underdeveloped, indigenous firms often look abroad to source the capabilities they need. The positive role of international business connections in enabling technological and economic development has been known since at least the early work of Dunning (1958). Some of those connections are forged through the flow of people (Saxenian, 2002, Vang and Overby, 2006), but they often take place through the course of business. However they take

place, the contact with the managerial and technological innovations of partners from more advanced innovation systems help accelerate local development.

Where leading MNCs invest in the developing world, such connections tend to take place primarily through the hierarchy in the interaction between the subsidiary and its headquarters (e.g. as discussed in the work of Marin and Arza in this volume). But connections can also take place through markets, e.g. through imports and exports, franchising or licensing (Lall, 2001b). In the case of South Korea, where upgrading took place through the development of strong indigenous firms rather than through incoming FDI, market transactions were important throughout the upgrading process, from the imports of capital goods and turnkey factories in the 1970s to the licensing of key technology in the 1980s, through to outward FDI, i.e. exposure to more sophisticated markets in the developed world (Miotti and Sachwald, 2001).

For champion firms, there are three attractions to market transactions with foreign partners. First, the expectation of social obligation is reduced. Second, market transactions provide the opportunity to engage with partners who may well be more competent than the government actors in a developing country. Finally, champion firms can engage on a more equal footing with those partners than with their government. But while it is clear how an international focus can help champion firms to upgrade their capabilities, it is less clear how – if at all – that focus can assist in the upgrading of their home countries.

### 9.2.5. Models for interaction between national champion firms and their underdeveloped innovation systems

[Figure 9.2 about here]

The contribution that a champion firm makes to upgrading in its home country will be shaped by its efforts to negotiate three main tensions. First, a champion firm needs to fulfil its social obligation to the state, but also engage as a for-profit entity with other firms that act much more purely out of self interest. Second, in its interactions with its main stakeholder, the state, the champion firm is the less powerful actor. The combined expectation of social obligation and lower power limits the ability of a champion firm to challenge the state, even when it is negatively affected by state actions. Third, the market offers the possibility of more equitable interaction and a reduced expectation of social obligation, but because markets and market partners in developing countries are often underdeveloped, champion firms often have to engage with global rather than local partners.

We propose that national champion firms resolve these tensions in three distinct ways, by seeking to resolve them at a global, national or firm level (see Figure 9.2). These strategies are not mutually exclusive: For example, irrespective of how global its orientation, a national champion firm is anchored in (and needs to interact with) a particular national institutional infrastructure. However, the framework provides a useful conceptual tool for interpreting champion firms' strategies for upgrading and how (or not) they contribute to their national innovation system.

**Co-evolution through a national focus**

A national orientation offers the greatest potential for broad-based upgrading, because co-evolution is possible to the extent that a firm is in productive dialogue with other partners in the national innovation system. The most comprehensive study of such co-evolution is Murmann's (2003) work on the chemical industry in Germany, the UK and USA. In the most successful case, Germany, chemicals firms actively worked to shape their national context. Murmann identifies three key mechanisms enabling the co-evolution between technology, firms and institutions: The exchange of personnel (e.g. individuals often moved between firms and universities), the formation of commercial ties, and government lobbying, e.g. for sympathetic patent laws and for expanded state support for education and research.

All three these mechanisms serve to reconcile tensions in the action motive (self interest or social obligation) and to create a more equitable distribution of power. Even in the absence of a formal organisation that can serve to limit pure self interest, personal relationships introduce social rules and obligations. Industry organisations resemble champion firms in that they have a mixed – self interest and social obligation – action motive (Hollingsworth, 2000). Moreover, because the tensions between the market and hierarchies are mitigated by collective action, such action achieves greater equity of power between firms and the state.

National champion firms can potentially play a leading role in the coordination of other local economic actors. They can spearhead the development of industry associations, can engage in dialogue and lobbying with the state (on their own or within a formal association) and can lobby the education and research sector to develop the capabilities they most need. Where capabilities are not locally available, champion firms can source

capabilities not only for their own use, but also play an important role brokering between foreign and local capabilities.

In other words, the national focus does not preclude drawing on international linkages. Instead, it takes as point of departure that the presence of such linkages is worth little without a supportive local institutional base. There is by now an extensive literature documenting that "spillovers" from foreign investment occur best where there is also engagement with and investment in the local capacity base (Blomström, Kokko, and Globerman, 2001, Haddad and Harrison, 1993, Marin and Bell, 2006) and where champion firms invest effort to develop the home country capacity base more broadly, upgrading and accelerated development can occur.

**Global enclave formation**

An alternative strategy is to focus almost exclusively on the international context. Firms can disengage from the local context and draw most of their resources from abroad to such an extent that they operate virtually as enclaves within their own country. Enclave formation has been documented mainly for incoming FDI (e.g. Akbar and McBride, 2004, Kelegama and Foley, 1999), but the implications for champion firms of the complex interaction between foreign enclaves and local firms (e.g. Bowen, Leinbach, and Mabazza, 2002, Feinberg and Majumdar, 2001) are worth exploring.

It is possible for benefits from enclaves to spill over to the host economy, e.g. in the case of FedEx's principal South East Asian hub. FedEx operates its hub from Subic Bay, a former US naval base in the Philippines, and the hub has been conceived and managed as an enclave to such an extent that it was unaffected by the Philippine ban on air travel to Taiwan in 1999 and 2000 (Bowen, Leinbach, and Mabazza, 2002). But an

analysis of the users of the service demonstrates significant use by Philippino firms, in addition to more developed regional users, e.g. from Singapore. The main predictors of the use of air cargo services are the knowledge intensity of products, firm size and a firm's degree of internationalisation (Bowen and Leinbach, 2003). In other words, the enclave did result in the development of some local linkages, particularly with the most competent local firms.

Much as an emphasis on quality bodes well for capability upgrading and innovation, it is also one of the main drivers of enclave formation. Dunning (1989) points out that where quality and differentiation are important motives, multinationals tend to cater for the international and/or top end of markets. This tends to weaken linkages with the local economy: Empirical work confirms that where quality is a motive, multinationals are more likely to be wholly-owned subsidiaries with a large proportion of expatriate employees (Bouquet, Hébert, and Delios, 2004), more likely to enter into alliances with other multinationals rather than with local firms (Aung, 2000), and more likely to serve other multinationals than local customers (Akbar and McBride, 2004).

Leading firms in developing countries may similarly decide to emphasise connections from better developed foreign countries rather than engage in the uncertain process of trying to develop such linkages in their home country. Dunning (1998) points out that critical skills – "created" assets – are not only fairly mobile (e.g. embodied in people) but also as a rule owned by firms and in terms of Figure 9.1, many of the market elements can be conceivably sourced abroad. Although the acquisition of the more location-bound, non-market elements is likely to still be shaped by the national context, firm-level upgrading within an enclave is unlikely to result in extensive benefits to the less developed home country.

**Internalisation with a firm-level focus**

The third possible strategy involves the internalisation of activities. With this strategy, the firm assumes responsibility for tasks that would otherwise be performed by other actors in the local innovation system. The most typical expression of this process of internalisation is conglomeration. Conglomerates are often found in developing countries, and various authors argue that the bringing together of diverse capabilities within a single corporate entity is a rational response to the "institutional voids" and systemic inadequacies in their home countries (Amsden and Hiking, 1994, Khanna and Palepu, 1997, Khanna and Yafeh, 2007). In principle, the process of internalisation can also take place without conglomeration, for example when firms set up not-for-profit internal training centres, or develop back-up power generation facilities to compensate for weak national provision. What makes this process distinctive is that firms narrow their focus to exclude as much of the national context as they can.

National champion firms seem unlikely candidates for a strategy characterised by a retreat from the national context, but it is important to bear in mind North's insistence that institutions are not necessarily efficient (1990). Champion firms may well find themselves unable to fulfil the mandate with which they have been charged unless they assume direct control of some responsibilities that are normally provided nationally. To the extent that their actions benefit the wider national context, a predominantly firm-level orientation can be beneficial. However, those benefits are likely to occur only incidentally.

In short, the fact that some indigenous firms have managed to evolve into competent global players cannot necessarily be interpreted as evidence that the national innovation system has co-evolved with those firms. It is necessary to consider the specific partners

that the firm has been interacting with and the pattern characterising those interactions. This study investigates those patterns by looking at the South African firm, Sasol.

## 9.3. Sasol, a champion firm in South Africa

The study investigates the case of Sasol, the only South African firm on UNCTAD's list of the top R&D spenders in the world (516$^{th}$ worldwide) with an R&D spend of $91m in 2003 (World Investment Report, 2005). Sasol today can be considered a small multinational corporation, but it started out as a national champion firm. It is therefore a useful lens through which to examine the relationship between the evolution of an indigenous firm and the evolution of its innovation system.

Sasol's origins lie in the Fischer-Tropsch (FT) process for generating fuel from coal and gas, so named after the two scientists who patented the process in 1925 in Germany. Early exploitation of FT was consistently politically rather than economically motivated: British and American firms in the 1930s had already investigated the FT process and concluded that it was not commercially viable, but interest in FT was revived during the Second World War, when it was an important part of the German energy self-sufficiency strategy (Collings, 2002). Similarly, the process had been investigated in South Africa from at least 1937, when the mining firm Anglovaal had acquired the rights to the patent. In 1949, after Anglovaal had concluded that synthetic fuels were not commercially viable, the newly elected National Party government stepped in. The desire of government to increase national self-sufficiency was central to the creation of the firm. Sasol was founded in 1950 as a synthetic fuels firm, received

considerable direct state support until 1979, and informal support until the end of National Party rule in 1994.

We follow the evolution of Sasol from its founding in 1950 until 2005, using a variety of data sources. Newspaper articles, company publications and annual reports from 1957 onwards are used to highlight the broader economic, socio-political and technical context within which Sasol has been operating. We then identify key periods in Sasol's technological upgrading by considering its scientific publications and patenting portfolio, as well as the commissioning of synthetic fuel reactors. The plants embody the most advanced technology of the firm at the time, and thus punctuate the Sasol history. Only the most recent of Sasol's five eras (see Table 9.1) is associated with globalisation; all the others with increasingly advanced reactors.

[Table 9.1 about here]

The specific external elements that have been supporting innovation by the firm (see Figure 9.1) are mapped in terms of the five eras in the evolution of Sasol. The different elements and their embeddedness within the firm are discussed, and finally the nature of their impact on the national innovation system is distilled.

## 9.4. Models of interaction between Sasol and the national innovation system: the importance of distinguishing between markets and hierarchies

Two processes were critical in the creation of Sasol: First was the insistence and support of the South African government in founding the firm. Second was the technology of foreign partners to jumpstart the fuel-from-gas process. Because there was no local expertise available, the South African Liquid Fuels Advisory Board had visited the US, UK and Germany before deciding on MW Kellogg technology for transportation fuels, and technology resulting from a joint venture between Ruhrchemie Aktiengesellschaft and Lurgi Gesellschaft fur Warmetechnik for the production of chemicals and wax. Early annual reports refer to them not as the "High Temperature" and "Low Temperature" FT processes, but as the "American" and the "German" syntheses, reflecting the strong association with the foreign suppliers of the technology.

At its founding, Sasol was acting as a broker between the underdeveloped South African context and cutting edge technologies from firms in the leading chemicals-producing countries in the world. Sasol continued to benefit from government support and international linkages (albeit with varying degrees) over the next number of decades, providing the ingredients needed to let Sasol play a constructive role in the evolution of the national innovation system. But analysis reveals that Sasol did not follow one clear mode of interaction, and as often met its needs by either globalising or internalising as by co-evolution with its home context. As the following discussion will illustrate, in the case of the less location-bound market elements, many of the actors in the national innovation system could not fully meet Sasol's needs, leading the firm to adopt a global

focus. In the case of more location-bound institutional elements, Sasol tended to internalise to compensate for systemic institutional weaknesses, rather than engage with its government in a way that would have involved confrontation, but could have led to co-evolution.

### 9.4.1. Market elements

A review of the important market elements – supply, demand and horizontal elements – in the evolution of Sasol reveals a general reliance on foreign sources of expertise (see Table 9.2).

[Table 9.2 about here]

Given Sasol's mandate as a domestic provider of fuel, *demand* initially had a strong domestic focus, but because fuel is a commodity, Sasol neither benefited nor suffered from this focus. Sasol started to expand into a range of other chemicals during the anti-Apartheid era, and political pressures made it hard to tap into more competitive foreign markets. However, its customer base did expand to include the large South African firms, e.g. the globally competitive mining houses. The further specialisation of its product range (initially Sasol expanded only into commodity chemicals, but from the 1990s onwards also into specialty chemicals) coincided strongly with increasing global openness. Sasol resembles most other developing country firms in the way in which the sophistication of its offering increases with its openness to a foreign customer base.

With regard to its *supplier relationships*, Sasol behaves almost like a foreign multinational in its tendency to procure raw materials (especially coal) locally, but to

source its more complex needs from abroad. One of the reasons for this pattern is that Sasol for long did not operate in an industry where similar local firms were active. Murmann (2003) documents industry-level interaction as one of the key mechanisms through which institutions in an innovation system co-evolve, but until the founding of Mossgas in 1987, there were no other firms operating in the same field in South Africa, limiting the ability of Sasol to operate within a collective. Once competition emerged, even though the industry was embryonic and consisted of only two firms, both of which extensively sponsored by the state, it did result in changes like Sasol starting to systematically patent, rather than rely on secrecy to protect its technological advances.

Similarly, Sasol's *alliances and acquisitions* are almost exclusively with foreign partners. This pattern is seen across all eras in the Sasol evolution, from the first era when a joint venture took place between Sasol, Total and the National Iranian Oil Company in 1971, to the fifth when Sasol purchased Condea, the German chemicals firm in 2001. The sustained emphasis on foreign relationships suggests that at no time was there adequate capacity locally to support the technological upgrading of Sasol. Other than Mossgas, which drew extensively on Sasol expertise, there were no other firms in South Africa using similar technology. In terms of general economic upgrading in South Africa, the impact of Sasol was limited. Ironically, given the strong emphasis on self-sufficiency that prompted its founding, Sasol basically operated as an enclave among South African businesses.

### 9.4.2. The state and its agencies

The state and its agencies are more location-bound than the market elements, and interactions with them therefore potentially offer a greater opportunity for influencing the national innovation system. Two factors are particularly important to understand the interaction between Sasol and the state and its agencies. First is the relationship between Sasol and the two governments under which it has functioned. Second is Sasol's relationship with the national education system. Given the very clear link between education and upgrading at both the firm and country level (e.g. Bell and Pavitt, 1992, Hobday, 1995a, Kim and Nelson, 2000, Lall, 2001a etc.), it is a good setting for examining the potential influence of Sasol on its innovation system. Education acts as a concrete manifestation of the relationship between a national champion firm and its government. The section on the Education infrastructure therefore discusses in detail how Sasol used internalisation to respond to the inadequate educational infrastructure under the Apartheid government, and how there was greater co-evolution once the ANC government came to power.

[Table 9.3 about here]

**Governments**

At first glance, there is no reason to expect tension between Sasol and the National Party government that founded it. Sasol was the recipient of extensive government support, both Sasol and the government were motivated by goals of self-sufficiency, and both were Afrikaans-dominated (e.g. the early Sasol research reports were almost

always written in Afrikaans). But tensions were evident from the first era in Sasol's history, and an analysis of the tensions points to the importance of aligning not just a general ideology, but specific goals.

Already in Sasol's first era, the government wanted dramatic expansion ("Sasol II"), but Sasol was concerned about the availability of skills to support such expansion. In the end, the government not only pushed through its first expansion plan, but also a second ("Sasol III"). The dilution of the skills base led to an almost 9% drop in productivity at Sasol I (Sasol Annual Report, 1979) and required Sasol to invest extensively in training to restore morale and regain productivity. The expansions were so large that the government could not independently fund them. Sasol was therefore privatised (in 1979, its second era), which caused some concern in government circles about a potential loss of control of the strategic direction of Sasol. Of course, Sasol was still benefiting from extensive subsidies, tariffs, synlevies and other forms of financial support from its government – there were a number of levers that could be used if Sasol were to fundamentally challenge the government.

In its second and third eras, Sasol's close association with an increasingly tainted government was a growing source of tension. Within South Africa, Sasol was a frequent target of anti-Apartheid activities, suffering extensive labour upheavals and a bombing in 1980. As global censure of Apartheid increased, resulting in economic sanctions and an academic boycott, Sasol also found it increasingly hard to sustain its critical global linkages, and even long-term collaborators like Westinghouse retreated from working with Sasol. Sasol was reliant on a range of foreign collaborations to sustain its technological advancement and could ill afford to be excluded from global knowledge networks. But it could also not afford to jeopardise the extensive financial support it

was receiving from the government. With the very defensive but powerful government unwilling to engage in productive dialogue with Sasol, and with global relationships being boycotted, Sasol relied on internalisation to circumvent the problems posed by an underdeveloped institutional infrastructure.

The tension between Sasol wishing to assert its independence, and the government wishing it to fulfil a social agenda has remained present across the different eras, although the social agenda of the new African National Congress (ANC) government was very different from that of the National Party government. The government change over the fourth and fifth eras introduced a new type of tension. Sasol was evolving into a small but typical multinational, and was keen to expand its focus globally. Its important goals all had an international focus, e.g. to generate 50% of Sasol's cash from operations from non-SA operations by 2010 (Sasol Annual Report, 2005). At the same time, the ANC government wished to increase the participation of black South Africans in both science and the economy, and they saw Sasol as an important partner in achieving these goals.

Sasol's interaction with the ANC government sheds light on how lasting are firm routines, as well as the importance of aligned incentive structures rather than an ideological connection in developing the innovation system of a country. The ANC never had the same kind of direct power over or ideological link with Sasol that the National Party government had. By the time the ANC government had come to power, government subsidies were being phased out and Sasol was no longer a true national champion firm. Although it was one of the leading firms in South Africa with a large employee and revenue base, Sasol had over the decades developed routines for interacting with government, and those routines and linkages proved powerful enough

to remain in place even after the change of government and a change in the core mission of Sasol. In addition, in the arena of education the incentives of Sasol and the government were clearly aligned: To increase the supply of scientists and engineers. With aligned incentives, Sasol and the ANC government were able to engage in a co-evolutionary manner.

**Education infrastructure**

Sasol's achievements in terms of advanced science are impressive. By 1958, struggling to commercially develop a proof of concept plant, Sasol had established a formal R&D department and over the next decades, Sasol developed into a global leader in its niche technology, with a wide patent portfolio. The evolution of its scientific capability base can be seen from the increasingly high impact factor of journals in which Sasol published (see Table 9.4). Although local universities played an important role in the skills development of Sasol scientists, Sasol already in the 1960s sent employees for studies abroad to source specialised knowledge. Sasol was ahead of its time in recognising that good quality domestic science was more than an expensive "luxury" for developing countries.

Nowadays industrialising countries are putting enormous effort into building their universities and research institutes early in their upgrading. The relationship between firms and universities and public research institutes in the domestic innovation system is now recognised as important in technological upgrading from the start (see Chapter 11 by Lundvall et al. in this volume for a detailed discussion of the role of universities in innovation systems in developing countries).

However, the academic boycott had interrupted the benefits of Sasol's early interaction with both local and foreign universities, and in fact had a lingering effect not only on Sasol, but also on South African universities. In its fifth era, after the academic boycott had ended, Sasol moved swiftly to restore international contact and established two research groups with mainly foreign members to develop (in Homogenous Catalysis) and strengthen (in Heterogeneous Catalysis) its research capacity. Sasol also played an important role in brokering relationships between the South African universities and wider catalysis research network, e.g. by including local academics on its advisory boards.

Sasol entered into research partnerships with the Universities of Cape Town and Johannesburg in South Africa, as well with the universities of St Andrews in Scotland and Twente in the Netherlands. According to Cantwell and Athreye (2007), once late industrialising countries have developed basic capabilities, they can – and should – participate in globally connected rather than localised research networks. The case of Sasol very closely follows this pattern. Research institutions look for partners with a proven track record and potentially productive research avenues, and the involvement of reputable foreign public research institutions not only enables accelerated capability development, but also points to the achievement of a significant level of expertise on the part of Sasol. By developing a small, highly skilled research base, and by developing its foreign networks (e.g. the US firm Fluor and the German firm Linde), Sasol had managed to build a strong R&D program.

[Table 9.4 about here]

However, various authors (e.g. Lall, 2001c, Pack, 2000) point out that skills upgrading at all levels is important for systemic development to take place. And in terms of skilled technicians and engineers, Sasol struggled from its inception. Shortly after the founding of Sasol, the National Party government passed the "Bantu Education Act". The act was intended to ensure white domination by providing inferior education to blacks, and marks a fundamental fault line between Sasol and its government. Sasol was a science-based firm that needed skilled employees to function. Sasol suffered a skills shortage through all five the eras, and engaged in a number of initiatives to mitigate that shortage. It established a bursary scheme for study at South African universities in its first era, and consistently expanded it. Although the government had by 1959 established a dedicated technical training centre in Sasolburg, Sasol continued to supplement that training by investing extensively in in-house training. In the years after the commissioning of Sasol II and Sasol III, Sasol spent 5% of turnover on training to restore productivity to previous levels.

Strikingly, all of these initiatives were within-firm initiatives. Sasol did not engage directly with its government about the need to improve general education and training. With the school riots in 1976, education had turned into a battleground in the anti-Apartheid struggle. During its second and third eras, from 1976 to the election of the ANC in 1994, Sasol did not intervene to halt the increasing bifurcation between the stable white and under-resourced, conflict-ridden black schools and universities, even though 80% of the population (and potential workforce) was black. The Bantu Education Act was a cornerstone of the government's Apartheid policy, and given its close and unequal power relationship with the government, Sasol did not engage in dialogue with the government about education reform. Instead, Sasol used the resources

that were nationally available – e.g. graduates from the well-functioning white education system – and used internalisation to compensate for shortages.

This changed in 1994, which marks both the end of Apartheid and the beginning of the phasing out of subsidies for Sasol. The incoming ANC government started seeking ways to redress decades of neglect in the black education system and in turn, Sasol started engaging directly with the national education infrastructure. It assumed a leadership role on national forums to improve technical training, advised the government on educational restructuring, and even intervened directly in the provision of education, e.g. by providing funding to a number of local universities. In terms of education, Sasol engaged in the type of behaviour that characterises co-evolving national innovation systems throughout its fourth and fifth eras.

Much as Sasol was focused primarily on establishing a global footprint during those eras, the goals of the ANC government – in this case, importantly increased black participation in science and business – were not incompatible with a greater global presence. Faced with both the location-bound nature of institutional resources and a government where there were potential synergies between the needs of Sasol and those of its national government, co-evolution started to occur.

## 9.5. Discussion and concluding remarks

A report of the Carnegie Commission in 1932 reported that about a third of Afrikaners – displaced by urbanisation and the Anglo-Boer war, and lacking the skills to function in an urban economy – were living below the poverty line (Steyn, 2004). When the National Party government came to power in 1948, its policies were informed by a

single-minded preoccupation with the economic and educational upliftment of Afrikaners. The scientific achievements of the small cadre of researchers at Sasol fit that vision. But underlying the Apartheid ideology is also an assumption that innovation need not take place in a systematic manner; that systematic underinvestment in one part of the population would not affect upgrading in general.

[Figure 9.3 about here]

To the extent that a dominant impression of the diverse contributions of the wide range of partners that have been shaping innovation and upgrading at Sasol since its inception (see Figure 9.3 for a summary) can be formed, Sasol's interaction with innovation partners reflects the type of thinking found in the National Party government. Innovation at Sasol has been informed by a belief that one should engage with an uncertain environment by defining a narrow focus area, and then investing heavily in it. It is of course a key tenet of the national innovation systems literature that firms will be shaped by formal and informal practices and policies in their environment, and that those firm routines will persist even once environmental factors have changed. But the fact that Sasol had inherited from the National Party government a preference for concentrating its efforts on niche areas, also suggests that Sasol's influence on the national innovation system would be limited to a few narrow spheres.

There are examples of how national innovation systems were fundamentally transformed by the upgrading of a few large firms. Over the past half-century that role was fulfilled both by Toyota and the keiretsu in Japan, and by Samsung and the chaebols in South Korea. But in those cases the firms were also at the vanguard of a

new technological paradigm (Cantwell, 1992, Kodama, 1992). In the case of Japan, Toyota ushered in the use of electronics and distributed decision-making in the production process, and in the case of South Korea, Samsung became a key provider of semi-conductors. In contrast, Sasol was operating in a mature industry, chemicals, where leadership positions were already so well established that it is hardly surprising that Sasol had become a niche player.

Even when they are not pioneers in an important emerging technology, leading developing country firms may be able to influence national development more generally. This would involve them being both nationally and globally embedded, coordinating activities within their own less developed innovation system, and acting as brokers between those innovation systems and the more developed global innovation system. The ideal interaction between national champion firms and the national and global innovation systems is highlighted in Figure 9.4.

[Figure 9.4 about here]

At its founding, the potential existed for Sasol to play such a role. But its evolution outpaced that of the national innovation system, and consequently the role of local partners increased only marginally over its evolution. Because other local firms had so little interaction with a competent partner such as Sasol, they reaped only limited benefit from its presence. In spite of the large contribution that Sasol was making to energy self-sufficiency in its domestic economy, it was increasingly acting as an enclave in it. Only with the election of the ANC and the subsequent revisiting of national policies (see Figure 9.5) did that pattern start to change.

[Figure 9.5 about here]

Generalising from the Sasol case, it is possible to identify a number of reasons why national champion firms may play a limited role in the shaping of their local innovation system. First, a leading firm in a developing country is unlikely to draw on weak partners in the innovation system from which it evolves if it can fulfil its needs elsewhere. Even in the 1950s – and increasingly so in a globalised world – a firm could interact with sophisticated suppliers, buyers and horizontal partners from across the world, rather than limit its focus to less developed partners in its own country. Interaction with other local firms tends to be limited to two types of firms. First, leading firms do interact with other leading firms in the developing country; in the case of Sasol, it provided explosives to the sophisticated South African mining industry. Second, the firm tends to follow the pattern of behaviour of foreign multinationals, and uses the local innovation system for its less knowledge intensive needs (in Sasol's case, the provision of raw materials).

Locally anchored national institutions have a greater potential to interact in a synergistic way with leading local firms, but it still cannot be assumed that leading firms will necessarily contribute to national capability evolution. The case of Sasol clearly demonstrates that the co-evolution of firm and national capabilities will occur only to the extent that there is alignment in the goals of both the firm and its government. Because inferior education for blacks was a cornerstone of Apartheid, Sasol was not in a position to challenge the education provision of the National Party government, even though it persistently suffered from a shortage of skills. At the level of advanced technology creation, however, Sasol benefited from its government's desire for energy

self-sufficiency and demonstrable scientific expertise. Sasol was able to rely heavily on foreign partners (foreign training, formal and informal research collaborations, advisory boards etc.) to support its R&D efforts, but because the foreign partners were less appropriate for providing training for its technicians and engineers, Sasol responded by internalising as much of education provision as it could. In the post-Apartheid era, Sasol abandoned neither its foreign relationships nor its internalised training provision, but it also started interacting directly with government about those elements of the innovation system.

One of the subtexts of the current enthusiasm about emerging multinationals from less developed countries is that they signal accelerated development on the side of those countries. The study of Sasol challenges the assumption that strong firms will necessarily contribute to the upliftment of the country as a whole. Although it is in principle possible for firms to co-evolve with their home country, it is by no means an inevitable relationship. Competent firms will seek out other competent firms as suppliers, alliance partners or even (industrial) customers. Where there are other firms in the developing country that could meet the needs of a strong national champion firm, its presence could have the same beneficial effect as technologically advanced foreign multinationals. But if the firm is substantially more advanced than other local firms, it is more likely to establish those relationships with foreign rather than domestic firms. It also cannot be assumed that the leading developing country firms can fundamentally change the institutional context within which they function. Although they can engage in dialogue with and lobby government and its institutions (e.g. educational system, patent laws etc.), they function within that context, and are limited in their capacity to

change it. However useful the contribution of even a large and successful firm like Sasol, national upgrading has to take place nationally.

This is not to say that national champion firms do not benefit their home countries. At a basic level, fuel from Sasol has been providing foreign exchange savings and a measure of domestic resilience against global oil crises. Second, Sasol has over time developed a substantial capability base, and its national champion roots still manifest themselves as sensitivity to the requirements of national government. To the extent that government has had sensible requirements, Sasol has been able to make a meaningful national contribution. Finally, Sasol has been playing a very important role in advancing scientific, technological and managerial expertise in South Africa. It has contributed immensely to strengthening the local chemicals research capacity, was responsible for the introduction of practices like international process control and management teaching in South Africa, and is still ahead of any other South African firm in terms of formal intellectual protection management. In other words, it acts as a local example for how to manage a science-based company. In sum, through its learnings and successes in science-based upgrading, Sasol has made a narrow but real contribution to innovation in South Africa.

## References

Akbar, Y. H., and McBride, J. B. (2004), 'Multinational enterprise strategy, foreign direct investment and economic development: the case of the Hungarian banking industry': *Journal of World Business*, **39**, 89-105.

Almeida, P., and Kogut, B. (1999), 'Localization of Knowledge and the Mobility of Engineers in Regional Networks': *Management Science*, **45**, 905 - 917.

Amsden, A. H., and Hiking, T. (1994), 'Project Execution Capability, Organizational Know-how and Conglomerate Corporate Growth in Late Industrialization': *Industrial and Corporate Change*, **3**, 111-147.

Athreye, S., and Cantwell, J. (2007), 'Creating Competition? Globalisation and the emergence of new technology producers': *Research Policy*, **36**, 209-226.

Aung, M. (2000), 'The Accor Multinational Hotel Chain in an Emerging Market: Through the Lens of the Core Competency Concept': *The Service Industries Journal*, **20**, 43-60.

Bell, M., and Pavitt, K. (1992), 'Accumulating technological capability in developing countries': *The World Bank Research Observer*, 257-282.

Bernard, R., and Oliviera, L. G., (2003), 'Building up complex productive systems in developing countries: the Embraer experience', in Cassiolato, J. E., Lastres, H. M. M., and Maciel, M. L. (eds.), *Systems of Innovation and Development: Evidence from Brazil*: Cheltenham, UK; Edgar Elgar, pp. 499-524.

Blomström, M., Kokko, A., and Globerman, S., (2001), 'The determinants of host country spillovers from foreign direct investment: a review and synthesis of the literature', in Pain, N. (ed.). *Inward Investment, Technological Change and Growth*: Houndmills, UK and New York, USA; Palgrave, pp. 34-65.

Bouquet, C., Hébert, L., and Delios, A. (2004), 'Foreign expansion in service industries: Separability and human capital intensity': *Journal of Business Research*, **57**, 35-46.

Bowen, J. T., and Leinbach, T. R. (2003), 'Air cargo services in Asian industrialising economies: Electronics manufacturers and the strategic use of advanced producer services': *Papers in Regional Science*, **82**, 309-332.

Bowen, J. T., Leinbach, T. R., and Mabazza, D. (2002), 'Air Cargo Services, the State and Industrialization Strategies in the Philippines: The Redevelopment of Subic Bay': *Regional Studies*, **36**, 451-467.

Cantwell, J., (1992), 'Japan's industrial competitiveness and the technological capabilities of the leading Japanese firms', in Arrison, T. S., Bergsten, C. F., Graham, E. M., and Harris, M. C. (eds.), *Japan's growing Technological Capability: Implications for the US Economy*: Washington DC; National Research Council, pp. 165-188.

Cantwell, J., and Fai, F. (1999), 'Firms as the source of innovation and growth: the evolution of technological competence': *Journal of Evolutionary Economics*, **9**, 331-366.

Cantwell, J., and Vertova, G. (2004), 'Historical evolution of technological diversification': *Research policy*, **33**, 511-529.

Chaminade, C.; Vang J. (2006), ‘Globalisation of Knowledge Production and Regional Innovation Policy: Supporting Specialized Hubs in Developing Countries’, *CIRCLE Electronic Working Paper Series*. 2006/15. http://www.circle.lu.se.

Chandler, A. D., (1997), 'The United States: Engines of economic growth in the capital-intensive and knowledge-intensive industries', in Chandler, A. D., Amatori, F., and Hikino, T. (eds.), *Big business and the wealth of nations*: Cambridge; Cambridge University Press, pp. 63-101.

Collings, J., (2002), *Mind over Matter: The Sasol Story: Half a century of technological innovation*: Johannesburg; Sasol.

Dantas, E., and Bell, M. (2006), 'The Development of Firm-Centred Knowledge Networks in Emerging Economies: The case of Petrobras in the offshore oil innovation system in Brazil', (ed.), *Druid Summer Conference*: Copenhagen.

Dodgson, M., (2000), 'Policies for Science, Technology, and Innovation in Asian Newly Industrializing Economies', in Kim, L., and Nelson, R. R. (eds.), *Technology, Learning, & Innovation*: Cambridge; Cambridge University Press, pp. 229-268.

Doloreux, D. (2002), 'What we should know about regional systems of innovation': *Technology in Society*, **24**, 243-263.

Dornseifer, B., (1995), 'Strategy, Technological Capability, and Innovation: German Enterprises in Comparative Perspective', in Caron, F., Erker, P., and Fischer, W. (eds.), *Innovations in the European Economy Between the Wars*: New York; De Gruyter, pp. 197-227.

Dosi, G., Pavitt, K., and Soete, L. L. G., (1990), 'The innovative process: international and intersectoral differences and determinants', in Dosi, G., Pavitt, K., and Soete, L. L. G. (eds.), *The Economics of Technical Change and International Trade*: London; Harvester Wheatsheaf, pp. 75-113.

Dunning, J. H., (1958), *American Investment in British Manufacturing Industry*: London; George Allen & Unwin, 365 pp.

Dunning, J. H., (1989), 'Multinational Enterprises and the Growth of Services: Some Conceptual and Theoretical Issues': *The Service Industries Journal*, **9**, 5-39.

Dunning, J. H., (1998), 'Globalization, Technological Change and the Spatial Organization of Economic Activity', in Chandler, A. D., Hagstrom, P., and Solvell, O. (eds.), *The Dynamic Firm: The Role of Technology, Strategy, Organization and Regions*: New York; Oxford University Press, pp. 289-314.

Dutrénit, G. (2006), 'Instability of the technology strategy and building of the first strategic capabilities in a large Mexican firm': *International Journal of Technology Management*, **36** (1-3), 43-61.

Dyer, J. H. (1996), 'Specialized Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry': *Strategic Management Journal*, **17**, 271-291.

Ernst, D. (2002), 'Global Production networks and the changing geography of innovation systems: Implications for developing countries': *Economics of Innovation and New Technology*, **11**, 497-523.

Feinberg, S. E., and Majumdar, S. K. (2001), 'Technology Spillovers from Foreign Direct Investment in the Indian Pharmaceutical Industry': *Journal of International Business Studies*, **32**, 421-437.

Figueiredo, P. N. (2003), 'Learning, capability accumulation and firms differences: evidence from latecomer steel': *Industrial and Corporate Change*, **12**, 607-643.

Figueiredo, P. N. (2008), 'Industrial Policy Changes and Firm-Level Technological Capability Development: Evidence from Northern Brazil': *World Development*, **36**, 55-88.

Florida, R., and Kenny, M., (2000), 'Transfer and Replication of Organizational Capabilities: Japanese Transplant Organizations in the United States', in Dosi, G.,

Nelson, R. R., and Winter, S. G. (eds.), *The Nature and Dynamics of Organizational Capabilities*: Oxford and New York; Oxford University Press, pp. 281-307.

Glaister, K. W., and Buckley, P. J. (1996), 'Strategic motives for international alliance formation': *Journal of Management Studies*, **33**, 301-332.

Granstrand, O., and Sjölander, S. (1990), 'Managing innovation in multi-technology corporations': *Research Policy*, **19**, 35-60.

Haddad, M., and Harrison, A. (1993), 'Are there positive spillovers from direct foreign investment?' *Journal of Development Economics*, **42**, 51-74.

Hobday, M., (1995a), *Innovation in East Asia: the Challenge to Japan*: Aldershot; Edward Elgar.

Hobday, M., (1995b), 'The Republic of Korea: catching up in large corporations', in Hobday, M. (ed.). *Innovation in East Asia: The Challenge to Japan*: Aldershot; Edward Elgar, pp. 51-94.

Hobday, M., (2000), 'East versus Southeast Asian Innovation Systems: Comparing OEM- and TNC-led Growth in Electronics', in Kim, L., and Nelson, R. R. (eds.), *Technology, Learning, & Innovation*: Cambridge; Cambridge University Press, pp. 129-169.

Hollingsworth, J. R. (2000), 'Doing institutional analysis: implications for the study of innovations': *Review of International Political Economy*, **7**, 595-644.

Kelegama, S., and Foley, F. (1999), 'Impediments to Promoting Backward Linkages from the Garment Industry in Sri Lanka': *World Development*, **27**, 1445-1460.

Khanna, T., and Palepu, K. (1997), 'Why Focused Strategies May Be Wrong for Emerging Markets': *Harvard Business Review*, **75**, 41-51.

Khanna, T., and Yafeh, Y. (2007), 'Business Groups in Emerging Markets: Paragons or Parasites?' *Journal of Economic Literature*, **45**, 331-372.

Kim, L. (1998), 'Crisis Construction and Organizational Learning: Capability Building in Catching-up at Hyundai Motor Corporation': *Organization Science*, **9**, 506-521.

Kim, L., and Nelson, R. R., (2000), *Technology, Learning, & Innovation*: Cambridge; Cambridge University Press, 377 pp.

Kodama, F., (1992), 'Japan's unique capacity to innovate: technology fusion and its international implications', in Arrison, T. S., Bergsten, C. F., Graham, E. M., and Harris, M. C. (eds.), *Japan's Growing Technological Capability: Implications for the US Academy*: Washington DC; National Academy Press, pp. 147-164.

Lall, S., (2001a), *Competitiveness, technology and skills*: Cheltenham, UK; Edward Elgar, 509 pp.

Lall, S., (2001b), 'MNCs, technology and export competitiveness', in Lall, S. (ed.). *Competitiveness, technology and skills*: Cheltenham, UK; Edward Elgar, pp. 188-259.

Lall, S., (2001c), 'Skills and competitiveness in developing countries', in Lall, S. (ed.). *Competitiveness, technology and skills*: Cheltenham, UK; Edward Elgar, pp. 128-187.

Lall, S., (2001d), 'What 'competitiveness' is and why it is important', in Lall, S. (ed.). *Competitiveness, Technology, and Skills*: Cheltenham, UK; Edward Elgar Publishing, pp. 1-30.

Lall, S., and Teubal, M., (2001), "Market-stimulating' technology policies in developing countries: a framework with examples from East Asia', in Lall, S. (ed.). *Competitiveness, technology and skills*: Cheltenham, UK; Edward Elgar, pp. 31-57.

Lautier, M., (2001), 'The International Development of the Korean Automobile Industry', in Sachwald, F. (ed.). *Going Multinational: The Korean Experience of Direct Investment*: London; Routledge, pp. 207-273.

Lee, K.-R., (2000), 'Technological Learning and Entries of User Firms for Capital Growth in Korea', in Kim, L., and Nelson, R. R. (eds.), *Technology, Learning, & Innovation*: Cambridge; Cambridge University Press, pp. 170-192.

Lee, K.-R., (2001), 'Technological Catching-up through Overseas Direct Investment: Samsung's Camera Business', in Sachwald, F. (ed.). *Going Multinational: The Korean Experience of Direct Investment*: London; Routledge, pp. 275-314.

Lundvall, B.-Å. (2002), *Innovation, Growth and Social Cohesion*: Cheltenham, UK; Edward Elgar, 219 pp.

Lundvall, B.-Å. (2004), 'Introduction to 'Technological infrastructure and international competitiveness' by Christopher Freeman': *Industrial and Corporate Change*, **13**, 531-539.

Marin, A., and Bell, M. (2006), 'Technology Spillovers from Foreign Direct Investment (FDI): the Active Role of MNC Subsidiaries in Argentina in the 1990s': *Journal of Development Studies*, **42**, 678-697.

Meeus, M., and Edquist, C., (2006), 'Introduction', in Hage, J., Meeus, M., and Edquist, C. (eds.), *Innovation, Science, and Institutional Change: A Research Handbook*; Oxford University Press.

Miotti, L., and Sachwald, F., (2001), 'Korean Multinationals' Strategies and International Learning', in Sachwald, F. (ed.). *Going Multinational: The Korean Experience of Direct Investment*: Studies in Global Competition: London; Routledge, pp. 127-166.

Mowery, D. C., and Nelson, R. R., (1999), 'Explaining Industrial Leadership', in Mowery, D. C., and Nelson, R. R. (eds.), *Sources of Industrial Leadership: Studies of Seven Industries*: New York; Cambridge University Press, pp. 359-382.

Mowery, D. C., Oxley, J. E., and Silverman, B. S. (1998), 'Technological overlap and interfirm cooperation: implications for the resource-based view of the firm': *Research policy*, **27**, 507-523.

Mowery, D. C., and Rosenberg, N. (1982), 'The influence of market demand upon innovation: a critical review of some recent studies': *Research policy*, **8**, 105-153.

Murmann, J. P., (2003), *Knowledge and Competitive Advantage: The Coevolution of Firms, Technology, and Institutions*: Cambridge; Cambridge University Press, 294 pp.

Nelson, R. R. (1992), 'National Innovation Systems: A Retrospective on a Study': *Industrial and Corporate Change*, 347-374.

Nelson, R. R., and Winter, S. G., (1982), *An Evolutionary Theory of Economic Change*: Cambridge, MA; Harvard University Press, 437 pp.

North, D. C., (1990), *Institutions, Institutional Change and Economic Performance*: New York; Cambridge University Press.

North, D. C., (1997), in Persson, T. (ed.). *Nobel Lectures, Economics 1991-1995*: Singapore; World Scientific Publishing.

Pack, H., (2000), 'Research and Development in the Industrial Development Process', in Kim, L., and Nelson, R. R. (eds.), *Technology, learning, and innovation*: Cambridge; Cambridge University Press, pp. 69-94.

Patel, P., and Pavitt, K., (1998), 'The Wide (and Increasing) Spread of Technological Competencies in the World's Largest Firms: A Challenge to Conventional Wisdom', in Chandler, A. D., Hagstrom, P., and Solvell, O. (eds.), *The Dynamic Firm: The Role of Technology, Strategy, Organization and Regions*: New York; Oxford University Press, pp. 192-213.

Perrin, S., (2001), 'The Internationalization of Korean Electronics Firms: Domestic Rivalry and Tariff-Jumping', in Sachwald, F. (ed.). *Going Multinational: The Korean Epxerience of Direct Investment*: Studies in Global Competition: London; Routledge, pp. 167-206.

Rosenberg, N., (1976), 'The machine-tool industry, 1840-1910', in Rosenberg, N. (ed.). *Perspectives on Technology*: Cambridge; Cambridge University Press, pp. 9-31.

Sachwald, F., (2001), 'Globalization and Korea's Development Trajectory: The Roles of Domestic and Foreign Multinationals', in Sachwald, F. (ed.). *Going Multinational: The Korean Experience of Direct Investment*: Studies in Global Competition: London; Routledge, pp. 361-382.

Sasol Annual Report (1971): Sasolburg; South African Coal, Oil and Gas Corporation, Limited.

Sasol Annual Report (1979): Sasolburg; South African Coal, Oil and Gas Corporation, Limited.

Sasol Annual Report (2005): Sasolburg; South African Coal, Oil and Gas Corporation, Limited.

Sauvant, K., (2008), *The Rise of Transnational Corporations from Emerging Markets: Threat or Opportunity?*: Cheltenham; Edward Elgar.

Saxenian, A., (1994), *Regional Advantage*: Cambridge, Mass and London, UK; Harvard University Press, 226 pp.

Saxenian, A., (2002), 'Transnational Communities and the Evolution of Global Production Networks: the Cases of Taiwan, China and India': *Industry and Innovation*, **9**, 183-202.

Schmookler, J. (1962), 'Economic Sources of Inventive Activity': *The Journal of Economic History*, **22**, 1-20.

Schrader, S. (1991), 'Informal technology transfer between firms: Cooperation through information trading': *Research Policy*, **20**, 153-170.

Simonin, B. L. (1999), 'Ambiguity and the process of knowledge transfer in strategic alliances': *Strategic Management Journal*, **20**, 595-623.

Song, J., Almeida, P., and Wu, G. (2003), 'Learning-by-Hiring: When is Mobility More Likely to Facilitate Interfirm Knowledge Transfer?' *Management Science*, **49**, 351-365.

Steyn, J. C., (2004), *Die 100 jaar van MER*: Cape Town; Tafelberg Publishers, 606 pp.

Teubal, M. (1996), 'R&D and Technology Policy in NICs as Learning Processes': *World Development*, **24**, 449-460.

UNCTAD (2005), 'World Investment Report: Transnational Corporations and the Internationalization of R&D': New York and Geneva; United Nations, United Nations Council for Trade and Development, pp. 332.

Vang, J. Chaminade, C.; Coenen, L., (Forthcoming 2008), 'Learning from the Bangalore Experience: The Role of Universities in an Emerging Regional Innovation System', in D'Costa, A. and Parayil, G. (Eds), *New Asian Dynamics of Science, Technology and Innovation (ST&I)*, Palgrave Macmillan. Series in "Technology, Globalization and Development".

Vang, J., and Overby, M. L., (2006), 'Transnational communities, offshore outsourcing and offshore subsidiaries: the case of the Indian IT industry', in Lundvall, B.-Å., Intarakumnerd, P., and Vang, J. (eds.), *Asia's Innovation Systems in Transition*: Cheltenham, UK; Edgar Elgar, pp. 54-74.

Von Hippel, E. (1986), 'Lead users: A source of novel product concepts': *Management Science*, **32**, 791-805.

Von Hippel, E. (1987), 'Cooperation between rivals: Informal know-how trading': *Research Policy*, **16**, 291-302.

Wasti, S. N., and Liker, J. K. (1997), 'Risky Business or Competitive Power? Supplier Involvement in Japanese Product Design': *Journal of Product Innovation Management*, **14**, 337-355.

NOTES

[1] In 1970, a subsequent director stated at his retirement: "We have succeeded in achieving something extraordinary in Sasolburg" Sasol Annual Report (1971).