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Shifts in Innovation Power to Brazil and India:
Insights from the Auto and Software Industries

Rasmus Lema, Ruy Quadros and Hubert Schmitz

February 2012

IDS Institute of Development Studies

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Summary

The global innovation map is changing. Until a few years ago innovation activities were concentrated in the US, Europe and Japan. Not anymore. The rising powers of China, India and Brazil are encroaching on the innovation stronghold of the old powers. This report explores how deep the change goes and how we can explain it. Most of the literature explains this shift in innovation power by concentrating on factors within the rising powers, such as their investment in high-level education, their low labour cost, their big and expanding internal markets and others. This report concentrates on explanatory factors that emanate from the old powers, notably the organisational decomposition of the innovation process (ODIP). The empirical focus is on the global value chains that link Brazilian auto and Indian software suppliers with lead firms in the US and Europe. The report shows that subsidiaries and independent suppliers in Brazil and India were involved in advanced innovation capabilities: they engaged not only in 'applied' development, but also in 'systemic' development of products and services. In other words, the build-up of innovation capabilities goes further than is generally recognised. Most of the report is then concerned with unravelling the processes through which this occurs, showing that ODIP emanating from US and European lead firms has knock-on effects within Brazil and India. The research also distinguishes between different types of ODIP showing that the biggest organisational and geographical changes occur when innovation and production activities are tightly integrated. The resulting build-up of innovation capability is only partially visible in conventional R&D indicators. The causal connection between ODIP in the old powers and increase of innovation capabilities in the new powers is not one way. The accumulation of innovation capabilities in the new powers increases the possibilities for further rounds of ODIP in the old powers.

Keywords: innovation; outsourcing; knowledge flows; global value chain; organisational decomposition; suppliers; Indian software industry; Brazilian auto industry.

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Acronyms

CAD	Customised Application Development
CoE	Centre of Excellence
CRM	Customer Relationship Management
D&E	Design and Engineering
DQ	Dataquest
ERP	Enterprise Resource Planning
ETL	Extract, transform, load
FDI	Foreign Direct Investment
GVC	Global Value Chain
HP	Hewlett-Packard
IB	International Business
ITS	Independent Testing Services
MIP	Made-in-India Products
MIS	Management Information System
MNC	Multinational Corporation
NASSCOM	The National Association of Software and Services Companies
NPD	New Product Development
ODIP	Organisational Decomposition of the Innovation Process
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer

OI	Open Innovation
OPD	Outsourced Product Development
PIPS	**P**IPS **I**s **P**OSIX on **S**ymbian OS
PVD	Physical Vapour Deposit
R&D	Research and Development
SET	Software Engineering and Technology
SUV	Sports Utility Vehicle
USPTO	United States Patent and Trademark Office

1 Introduction

The new millennium is young but in its first decade it has already seen successive global shifts of economic power: first in production power, then in financial power and now also innovation power. This report concentrates on the latter but needs to be seen in the context of the bigger picture.

1.1 Global shifts in economic power

The shift in economic power is clearest in the case of the manufacturing industry: the United States and Western Europe have de-industrialised and China has become 'the workshop of the world.' The Western services industry which initially seemed safe then began to outsource to India, which has subsequently become the world's leading software producer. These trends began in the old millennium but have consolidated in the new millennium. This shift in production power was followed by a shift in financial power which occurred not gradually but in the frenzy of the global financial crisis. The result is that Western states, being highly indebted, have little room for manoeuvre to finance the restructuring of their economies; and Western companies battle their way out of recession by seeking their fortune in the emerging markets. By targeting these emerging markets, one of the old powers – German industry – has been able to recover quickly. Otherwise, the picture is one of relative stagnation in the United States and Western Europe and continued rapid growth in the rising powers of China, India and Brazil.

The speed and depth of this global economic transformation is historically unprecedented. It would, however, remain incomplete if it did not include a build-up in innovation capabilities in the rising powers. There was the expectation – in the old powers – that they would keep the innovation jobs. In other words, letting the manufacturing and services jobs go would be okay as long as the most attractive jobs in terms of skill and income could be kept. Innovation activities were considered the bedrock of Western prosperity. Indeed, until the turn of the twenty-first century, innovation jobs were almost entirely concentrated in Western Europe, the United States and Japan.

Not anymore. Innovation activities outside the borders of the old powers are increasing, in particular in the rising powers of China, India and Brazil. Altenburg *et al.* (2008) show that China and India have embarked on the transition from production to innovation: the breakthrough is uneven and cutting edge innovation remains rare but adaptive innovation is significant in an increasing number of sectors. Equally important, innovation has not just occurred in technology but also in organisation and business models (Zeng and Williamson 2007). Brazilian innovations in the aircraft, energy and automobile industries have been internationally recognised (Monitor Group 2008). Sustainable biofuels have become the prevalent energy source for passenger cars in Brazil, as a result of the collaboration between the Brazilian agriculture, fuel and auto industries. This shift in innovation power, which is still in its early stages, is likely to continue because the emerging markets are becoming the lead markets for innovating companies. Western markets have not become irrelevant but are growing very little, if at all.

1.1.1 New realities – old language

These issues are big, complex and controversial. In order to have a tidy discussion it helps to clarify concepts, in particular the notion of innovation power and the grouping of countries. We find it useful to distinguish between production capabilities and innovation capabilities. The former refers to using and adapting existing knowledge. The latter refers to creating new knowledge and putting it to productive use. This distinction, which draws on the work of Martin Bell and colleagues,[1] is problematic because knowledge adaptation can be considered both part of the production, and of the innovation capabilities. Often there is a continuum between the two, but there is no *automatic* continuum. On the contrary, over recent decades the two have decoupled. While products and services made in the rising powers conquered world markets, there was no corresponding accumulation of innovation activities. They had production power but little innovation power. This is now changing in some sectors and firms. In this report, we are examining sectors and firms in which this is taking place.

When it comes to the global redistribution of these capabilities, the public and academic discourse is hampered by inadequate language. The old distinction of developing–developed continues to dominate internationally but hinders understanding. In continental Europe, the category of industrialised countries continues to be popular even though much of their industry has disappeared. The distinction of rich and poor countries remains more accurate because per capita incomes continue to differ substantially but (rising) intra-country differences between rich and poor regions is now the biggest concern, in particular in the rising powers. Reference to OECD countries is not useful for our purposes since the OECD includes now some of the emerging economies such as Korea, Mexico and Turkey. This report cannot escape the problem of inadequate country classification.[2] This is why we tend to name the countries we are concerned with, that is, Brazil and India on the one hand and the USA and Germany on the other. However, to make the report more readable we also use occasionally the language that is in common use, notably the contrast between old and new powers, or declining and rising powers.

1.1.2 Reasons for the global shifts in innovation power

While the different terminologies continue to confuse, it is clear that a global economic power shift has occurred in recent years. This report concentrates on the innovation dimension of this power shift. The recent literature points to a number of factors which explain the emerging shift in the global distribution of innovation activities. On the side of emerging economies, these include:

- Big state and private investment in higher education
- Low wages (compared with old powers) for highly educated workers

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1 This ‘capability approach’ emerged in the course of a number of articles, notably Bell (1984), Lall (1992), Bell and Pavitt (1995), Bell and Albu (1999), Figueiredo (2006), Ariffin and Figueiredo (2006).

2 For an in-depth discussion of the problems of country classifications, see Harris, Moore and Schmitz (2009).

- The return migration of engineers, scientists, and managers
- The insertion of local firms in global value chains
- The co-location (clustering) of local firms and support institutions in the developing world
- The increasing significance of lead markets in Asia and Latin America
- Governments 'trading market access for technology'
- Local enterprises circumventing intellectual property rights of foreign firms
- The enormous financial resources that government agencies and enterprises can mobilise to buy technology or research teams.

The relevance of these factors varies between countries and sectors. Even if all of them are considered they are unlikely to provide a sufficient explanation for the build-up of innovation capabilities in the rising powers. The old powers contribute to this build-up too. The most visible example is European and American firms setting up R&D facilities in China, India or Brazil. There are also less visible ways in which they contribute to the shift in innovation power. The main purpose of this report is to show how this occurs. In order to do this, we provide a conceptual framework for analysing these changes and detailed evidence from the auto and software sectors, in particular the value chains which connect the USA and Germany with India and Brazil.

Unpacking these connections is critical for understanding how the innovation power shift occurs and how deep it goes. What are the dynamics at work and what kind of innovation activities are affected? Public discussion – and much of the academic debate – provides a picture of old powers battling against new powers. This is misleading because some players operate on both sides of the fence. Showing this in itself is not so difficult but unravelling the dynamics which are then unleashed and tracing the outcome is difficult. This is what we are trying to do: opening a window into a process which is beginning to change the global division of labour and affect the global distribution of prosperity. Innovation jobs tend to be highly skilled and attract high incomes, so their location has ramifications also for those not directly interested in innovation itself.

1.2 The organisational decomposition of the innovation process

The starting point for our investigation is the organisational decomposition of the innovation process (ODIP) in the old powers (Schmitz and Strambach 2009). Over the last decade a fundamental change has occurred in the way innovation is organised. It tended to be concentrated at or near headquarters but is now much more decentralised within the company. Equally significant, innovation activities that used to be carried out in-house by innovating firms themselves are carried out by independent suppliers of knowledge intensive business services (KIBS), or are transferred to key suppliers. These organisational changes in themselves are not new; they have attracted a fair amount of discussion in the literature (for example, Chesbrough 2006; Coombs *et al.* 2003). There is, however, little systematic discussion of how they affect the global division of innovation activities.

This is in fact difficult to do because ODIP works in myriad ways. This report seeks to capture some of the main ODIP effects and to show how they influence the global shift of innovation activities.

To get a grip on these changes we follow Schmitz and Strambach (2009 and distinguish between:

- Decomposing the innovation process within organisations and between organisations – or internal and external ODIP.
- Delegating innovation to those who are primarily concerned with knowledge creation and those who are primarily concerned with producing a good or service.

These distinctions give a matrix of four types of ODIP (set out in chapter 3). Each type of ODIP has been going on within Western Europe and the USA for some time and each type has been discussed in the literature. What is missing is an investigation of how these ODIP types – on their own and in conjunction – affect the build-up of innovation activities outside Western Europe and the USA, in particular in the rising powers.

In principle it should become much easier for the latter to build up their innovation capabilities. They can acquire not just licences or private individuals but buy entire research centres or product development teams. Central corporate control over the innovation process is much reduced and competitors from any part of the world should find it much easier to target those bits of the innovation architecture which they most need. Surprisingly, there is no systematic analysis of rising power firms taking advantage of the organisationally decomposed innovation business in the old powers.

There is, however, increasing evidence of corporations headquartered in the old powers taking the initiative. They have established their own R&D facilities in the rising powers and they have commissioned innovation work to independent suppliers in the rising powers (UNCTAD 2005; Ernst 2009). In other words, they have engaged in cross-continental ODIP. In this report, we include these ODIP types but also examine others. And most importantly, we examine the knock-on effects.

1.2.1 The research questions

This report seeks to understand the dynamics which have been unleashed by ODIP emanating from the old powers and the implications for the build-up of innovation capabilities in the rising powers. It investigates in particular:

- How has the global value chain been reorganised? How has the lead firm altered the organisation of the innovation process? How has the division of labour changed between old and rising powers?
- What are the knock-on effects for organising the innovation process within the rising powers? Is ODIP being replicated in the new powers?
- What opportunities for building up innovation capabilities have been opened for the rising powers? Under what conditions can they take advantage of these opportunities? What kind of new innovation capabilities are emerging as a result? Do they include advanced capabilities?

- How does the build-up of innovation capabilities in the rising powers affect ODIP decisions in the old powers? Does it have an accelerating effect? Taking the longer view, what directions of causality become visible?

The report seeks answers to these questions by examining the auto industry of Brazil and the software industry of India and the value chains which link them to the USA and Europe. It shows how ODIP contributes to the shifts in innovation power, discusses the limits of this process and reflects on whether the old powers, having embarked on ODIP, are contributing to their own demise.

1.2.2 The value added

This study deals with a process of economic transformation which changes the division of labour and relationships between companies in old and new powers. They have been connected through global value chains for some time but the reorganisation of innovation activities in these value chains is relatively recent. Indeed, caution is needed in drawing conclusions because the changes are recent. This does not mean that they have a short history. As we shall see later, the new innovation capabilities built on previous production capabilities. How far do we need to go back in time in order to understand what has happened recently? We address this question in the concluding chapter of our report which brings out the limitations of our research.

A key task of this introductory chapter is to specify the value which this report seeks to add to the current debate. The value added is as follows:

a) Bringing together disparate but relevant strands of literature

The report draws on and brings together two lines of research about globalisation and innovation which have hitherto been disconnected: (i) work on the global decentralisation of innovation (or at least of R&D) along investment-centred value chains within MNC structures (Chen 2008; Hobday and Rush 2007; Marin and Bell 2010; Saliola and Zanfei 2009), and (ii) research about upgrading in ‘arms-length’ and trade-centred value chains (Ernst 2008; Giuliani *et al.* 2005; Morrison *et al.* 2008; Schmitz 2007). We integrate these in our ODIP framework that links the changing organisation of the innovation process with the spread of innovation through these value chains.

The report also connects two other literatures: the work on ‘open innovation’ which prioritises the implications within and between the old powers (Chesbrough 2006; Christensen *et al.* 2005; Cooke 2005; Simard and West 2006), and the research on the build-up of innovation capabilities in the new powers (Ariffin and Figueiredo 2006; Bell 2006; Bell and Pavitt 1995; Figueiredo 2006).

b) Conceptualisation

Despite the acknowledgment of increasing internationalisation of innovation, there is a dearth of theoretical frameworks to inform research into this phenomenon. Existing frameworks do not bring together the recent changes in both old and rising powers and neither do they include reorganisation within multinational firms as well as outsourcing to independent suppliers in global value chains. The analysis of the new geography of corporate innovation requires such a framework in order to capture the redistribution of innovation activities across the globe, both within and between firms.

As stated above, the starting point for this report is a new integrative concept for analysing the reconfiguration of innovation in and across enterprises: the organisational decomposition of the innovation process (Schmitz and Strambach 2009). We define ODIP broadly as the process by which firms shift elements of their innovation processes from their headquarters to decentralised departments, subsidiaries, research organisations and suppliers of products or knowledge-intensive services.

c) Including the less visible processes

In our empirical analysis of the different types of ODIP we do not just capture the visible and measurable changes such as lead firms locating new R&D labs away from headquarters in the rising powers. We also seek to throw light on the commissioning of activities which are not explicitly focused on innovation but bundled into work packages defined in terms of providing a product or service or making a process work. We show how engagement in seemingly peripheral innovation tasks opens up the path for encroaching onto more strategic tasks. And solving the problem of one customer provides the platform for taking on more demanding innovation work for other customers. For example, Indian software companies, tasked with solving the specific problems of their US customers, deliver innovations relevant to those problems and – in the process – open up paths for developing new products or systems.

d) Including the knock-on effects

The different types of decomposing the innovation process do not work in isolation and they have knock-on effects. For example, as shown later, the subsidiary of an auto-parts multinational company headquartered in Germany entrusts its Brazilian subsidiary with producing a better system, and this subsidiary in turn commissions research from local universities and involves local suppliers in developing and making the new product. Three different types of ODIP end up working in conjunction. Each type has been discussed in specialised literature providing insights on specific mechanisms of reorganisation, but grasping the bigger picture requires observing interdependencies and knock-on effects.

e) Directions of causality

Our main concern is to trace the implications of ODIP decisions made by European or US lead firms and to examine how they contribute directly and indirectly to the build-up of innovation capabilities in Brazil and India. This build-up in turn has changed the landscape in which the European and US lead firms operate. It puts them under pressure to innovate in cost-effective ways and delegate increasingly sensitive parts of the innovation process to suppliers which benefited from previous rounds of ODIP. In capturing the dynamics of the global reorganisation of innovation activities, we show how our understanding of the directions of causality changes once we examine the industries over a longer period of time.

1.2.3 Choice of sectors and locations

It is well established that the organisation of innovative activity differs across sectors – both between and within manufacturing and services. Yet we hypothesise that there are common changes across sectors. We therefore selected for study a manufacturing and a services sector. Of course, they needed to be important for both old and new powers. Automobile and software is a good choice for the following reasons.

- In the *automotive industry*, the offshoring of production functions to emerging markets was already evident from the mid 1970s and increasingly so in the 1980s (Sturgeon *et al.* 2008). It is now an industry that has globally integrated and effective value chains governed by so-called flagship firms (Ernst and Kim 2002). The organisational decomposition of the innovation process can therefore be considered along a fully developed global value chain.
- The globalisation of the *software industry* did not take off on a significant scale until the 1990s. However, it is a human-capital-intensive industry characterised by low transportation costs. It therefore carries a high potential for knowledge-mobility (Athreye 2005; Commander *et al.* 2008; Rousseva 2008). New clusters specialised in producing software have emerged, in particular in the rising powers.

This cross-sector comparative perspective is critical for gaining insights into whether the organisational decomposition of innovation has similar or different patterns in industries producing tangible and intangible goods.

As regards the geographical focus, we have concentrated on clusters in Brazil and India and the value chains which link them to lead firms in the USA and Germany. The software cluster of Bangalore in India and the auto cluster of São Paulo and other locations in Brazil seemed to be good candidates for our research. If ODIP is relevant for the build-up of innovation activities one would expect to find it here:

- Greater São Paulo is Brazil’s main car producing region. Its car industry was established by German and American companies much earlier than, for example, in Asian regions like Shanghai. In Greater São Paulo, a well-documented cluster emerged with substantial experience in building and upgrading the production capabilities of local suppliers (Humphrey 2003; Quadros 2004). Further clusters have emerged in other locations, notably in Campinas in the state of São Paulo and in Caxias do Sul in the state of Rio Grande do Sul. The latter specialises in trucks, the others more in passenger cars. These clusters have strong *production* capabilities – strong by global standards. The extent to which they have been able to accumulate *innovation* capabilities is disputed in the literature – as discussed in chapter 2.
- Bangalore, the capital of Karnataka state, has become a world-leading hub in the global software industry with a high concentration of global software firms and export-oriented local software service providers. The increasing possibilities for off-shoring software production to low cost locations have contributed to the changing geography of the IT industry and the development of specialised software clusters such as Bangalore. Its main source of growth

were exports – carried out by Indian and foreign-owned firms. Both benefited from knowledge transfer via the international mobility of skilled people. This occurred through ‘body shopping’, in particular in Silicon Valley, and through the return of highly skilled migrants (Arora *et al.* 2008; Athreye 2005; Bhatnagar 2006; Chaminade and Vang 2008; Commander *et al.* 2008; Saxenian 2004).

In assessing how ODIP affected these clusters, it is important to keep in mind in which respect they were similar or different in their starting conditions. The critical similarity is that – when we started our empirical investigation – both had attained world class standards in production capabilities. In the course of the research we then found substantial evidence of innovation capabilities in both cases – evidenced in later chapters. This provides a good basis for investigating *how* ODIP influences the build-up of innovation capabilities.

The following differences need to be kept in mind when comparing the two cases:

- The Brazilian auto industry produces mainly for the internal market and the Indian software industry mainly for external markets.
- The key players *within* the Brazilian auto industry are the subsidiaries of multinational companies; the main players *within* the Indian software industry are Indian-owned companies even though foreign subsidiaries are also present and important.
- Automobiles are complex products consisting of many (sub-) systems and produced in long value chains. Most software also consists of (sub-) systems but the value chains tend to be shorter.

These differences influence the way in which the decomposition of the innovation process unfolds. The report will show whether this leads to different outcomes in terms of the depth of innovation capabilities in Brazil and India.

1.3 The structure of the report

The report is structured as follows: chapter 2 provides a brief review of the literature on the Brazilian automotive and Indian software industry. It summarises what we already know about the issues raised in this report and provides context for further empirical analysis.

Chapter 3 provides the conceptual and theoretical basis of the paper. It sets out the ODIP framework that guides the empirical research. In doing so, it draws on insights from the International Business (IB) literature focused on multinational enterprises and their activities in emerging markets (Birkinshaw and Hood 1998; Hobday and Rush 2007; Narula and Dunning 2010; Saliola and Zanfei 2009) and on the Global Value Chain (GVC) literature (Gereffi *et al.* 2005; Giuliani *et al.* 2005; Morrison *et al.* 2008; Schmitz 2007). It also shows how this paper feeds into the debate about the new geography of innovation. Chapter 4 then explains the methodology adopted for the research presented in this paper, including the sampling strategy and the methods of data collection.

The remainder of this report sets out the empirical results. Before showing how ODIP has affected the build-up of innovation capabilities, it provides evidence that substantial innovation capabilities exist – since this remains a controversial topic. To this end, it draws on conventional indicators of innovation capabilities and on our own primary material. Chapter 5 shows that both our sample firms in the auto industry of Brazil and the software industry of India have been able to make the transition from production to innovation. Focusing on the Brazilian and Indian end of global value chains, we find that both have not only demonstrated capabilities of producing to international standards, but they have also begun to build up significant innovation capabilities, including some capabilities for advanced technology development and high-level systemic development.

Chapter 6 begins the discussion of how ODIP contributes to this build-up of capabilities. It shows how ODIP took different forms in the two industries. This is done by examining (global-scale) cross-border decomposition as practiced by lead firms that were connected to the innovation 'events' in Brazil and India. It shows that knowledge creation and learning have become processes that are increasingly segmented across geographies through multi-layered corporate networks that utilise and combine different types of ODIP. We illuminate how new strategies and practices adopted by lead firms have created new '*spaces*' for subsidiaries and suppliers in India and Brazil. However, we also discuss the *boundaries* of these spaces. We highlight in this section the typically strong connection between production and innovation activities in both cases. This is an important but often neglected dimension of the new geography of knowledge. Innovation networks are being built on top of global production networks; they are not replacing them.

Chapter 7 examines in more detail the implications of ODIP for 'local suppliers'. Comparing the two cases, it shows that ODIP takes different paths but the results in terms of building up innovation capabilities are the same. In the automotive case, there is a sequential pattern of intra-firm cross-border ODIP first, followed by inter-firm country-internal ODIP. The local auto-parts suppliers in Brazil tend to link up with the Brazilian subsidiaries of multinational assemblers or first-tier suppliers. They are not directly involved in the initial ODIP in Europe or the USA. In India, local suppliers typically deal directly with buyers located in Europe or the USA and are directly affected by their ODIP decisions. In spite of the different paths, the outcome for local suppliers is the same. In both cases, they become deeply involved in co-design. In both cases, this has occurred through a transformation of relationships with their customers. Information flows have become thicker, bi-directional, and include elements of tacit knowledge. In both cases, local suppliers have built up significant innovation capabilities – thus using the opportunities afforded by ODIP.

Chapter 8 emphasises that the accumulation of innovation capabilities is not an automatic outcome. It only happens if suppliers make the corresponding investment in people, equipment, organisation and relationships. In our sample firms, it was further aided by the leveraging of competencies across customers. The suppliers worked with and learnt from various customers, using the knowledge acquired in one chain to advance in another chain. Such capabilities of learning from external customers and making the corresponding internal investments could come to fruition because ODIP provided new opportunities but they did not originate in ODIP. They came from a history of learning and acquiring skills through various channels. The chapter therefore emphasises first, that there were multiple contributors to the deepening of innovation capability and second, that although ODIP created space for innovation, the effective exploitation of that space required significant new effort on behalf of suppliers.

Chapter 8 then increases the timescale and asks questions about the directions of causality between our two main variables: ODIP and the build-up of innovative capability. The previous chapters examine how the deepening of innovation capabilities in the two industries in Brazil and India was influenced by ODIP emanating from Europe and the USA. Taking the longer view, one can ask to what extent and how this ODIP was influenced by the accumulation of capabilities in India and Brazil. The direction of causation is not easy to establish. There was a push from lead firms in the USA and Europe, but this push was only possible because certain capabilities had already been acquired by Indian and Brazilian suppliers. Similarly, it is likely that the recent deepening of innovation capabilities by suppliers affects the ODIP decisions of their customers. Suppliers do not constitute a passive reservoir waiting to be approached by lead firms from Europe or the USA. Seen in conjunction, suppliers accelerate the pace of change; they change the landscape in which lead firms operate by increasing the options for new rounds of ODIP. In sum, the capabilities acquired by suppliers change the options available to lead firms.

The final chapter does two things: first, it brings together the main findings from this research and specifies the key advances made in relation to the literature. This includes a discussion of why we observe a more substantial shift in innovation power than most of the literature: is it because our research is more recent or is it because of the way we carried out research?

Second, it reflects on the future. This is done by setting out two scenarios:

- The first scenario is co-evolution of the old innovating regions in Europe and the USA and the new innovating regions in Brazil and India. Changes in one bring about changes in the other and vice versa. The division of labour changes, their specialisation profiles change but both regions move forward. The process is painful but the result is win-win.
- The second scenario also stresses intense interaction but the result is that one side loses and the other one wins. The loser is the old region which sees a decline in innovation jobs and economic prosperity. The winner is the new region which sees a rise in innovation jobs and prosperity. ODIP plays a critical role in this process. ODIP leads to a hollowing out of the innovation capabilities of the old regions and a corresponding deepening of innovation capabilities in the new regions. In other words, by embarking on ODIP, the old regions are digging their own grave.

Both scenarios are plausible but both need an analytical refinement. The economic region as a unit of analysis is not sufficient. We need to add the globally mobile enterprise as a unit of analysis. It relocates – or splits operations and locations – as new opportunities arise. The enterprise which was doing well in the old region might be the same as the enterprise doing well in the new region. Capitalism has become truly global. The innovation business is the last bastion of regional embeddedness. ODIP has started to erode this. We are moving closer to a world in which the innovative enterprise has no homeland. Are such homeless enterprises the real winners in this era of global shifts in innovation power? Only time will tell.

2 What do we know from the existing literature?

This short chapter pulls together the findings from the literature on the Brazilian automotive industry and the Indian software industry. It addresses three issues: (i) whether suppliers and subsidiaries have acquired (advanced) innovation capability, (ii) how lead firms organise the innovation process and (iii) how local suppliers are included in the lead firms' innovation networks. The chapter is concerned with bringing together the empirical findings from our two industries; conceptual issues are discussed in chapter 3.

2.1 The automotive industry in Brazil

The attainment of innovation capabilities in the Brazilian auto industry is a controversial topic. Much of the early literature on Brazilian innovation activities in the automobile value chain had a pessimistic view. For instance, Humphrey, Lecler and Salerno (2000: 11) found that while process-engineering skills required in the Brazilian automotive industry had risen because of increasing quality requirements and product complexity, design and product-engineering skills were less in demand. They expected that 'follow sourcing' and its match 'follow design' would become generalised practices in the motor industry, crowding out product-engineering capabilities in Brazilian owned OEMs. Similarly, Cassiolato *et al.* (2001) studied the Fiat cluster in the state of Minas Gerais. They sustained that, following internationalisation of the industry, 'R&D activities have almost disappeared in the cluster' and that the product development and engineering staff of Fiat was substantially reduced (Cassiolato *et al.* 2001: 9).

In contrast to this pessimistic view, an optimistic view emerged from other research which showed that – since the late 1990s – some leading multinational companies producing cars in Brazil have bet on locally developed products which were more aligned to the needs of local markets (Quadros and Queiroz 2001; Carneiro-Dias *et al.* 2003). Brazilian subsidiaries of multinational assemblers, particularly those with long experience in manufacturing, have enlarged R&D mandates and have stepped up their product-related technological activities. They specialise in designs relevant for their 'own' market and at the same time play an active role in the lead firm's global network. There is now substantial evidence of lead firms re-locating Product Development activities to Brazil and participating in their corporations' R&D networks (Consoni and Quadros 2006; Quadros and Consoni 2009; Dias *et al.* 2011). This shift, however, has been primarily focused on development and experimental activities, rather than on new technological research (Quadros and Consoni 2009). In parallel, Sturgeon *et al.* (2008), studying the motor vehicle value chain, recognised that *design and engineering* (D&E) remained for a long time concentrated in clusters around lead firm headquarters, but have recently been moved to new growth markets.

Compared to research on assembly lead firms and their innovative activities in Brazil, there is much less work on auto-parts suppliers. Few studies have explored how the global reorganisation of the auto industry has affected local suppliers' scope to build up their own innovation activities. Here the pessimistic view prevails. For example, Salerno *et al.* (2003), though recognising that local vehicle design and development can give local enterprises greater opportunities to participate in design, suggest that such potential was rarely realised. ‘The transnational companies that have a hegemonic role in the upper layers of the chain do the bulk of the auto-parts design activities’ (Salerno *et al.* 2003: 14). According to Salerno and his colleagues’ findings, Brazilian owned suppliers played only a minor role in product design and engineering activities although they had a somewhat increased role in process design. Indirectly they supported the rival hypothesis, namely that multinational assemblers encourage the big suppliers in their European and American home market to locate to countries such as Brazil (Humphrey 2003). If such ‘follow sourcing’ practices are adopted, the assembler subsidiary would then tend to reproduce supplier choices made by the parent company. Our later empirical chapters will follow this up and show whether this actually happened (see in particular chapter 7).

2.2 The Indian software industry

Most literature on the Indian software industry has also been pessimistic with regard to the build-up of innovative capability. The dominant argument is that Indian software firms have become strong in production/execution capabilities but have remained weak in innovation capability (Arora *et al.* 2008; Dossani 2006). The emphasis on ‘productive’ capacity is particularly strong in the works of D’Costa (see, for example, 2006, 2009). He argues that the rootedness of India’s competitive advantage in low labour costs gave rise to ‘extensive growth’, the linear expansion of the work force, without a corresponding increase in the deepening of skills. Indian firms tended to focus on the lower value-added stages of the software-development cycle in which learning opportunities were limited (see also Tschang 2005). However, like in the case of the Brazilian auto component suppliers, some recent studies emphasise the attainment of process capability. Athreye (2005) highlights the formation of strong process capabilities and organisational capabilities which were necessary to exploit the opportunity that arose with offshore outsourcing in the 1990s.

Research on lead firms in the software case is more ambiguous with regard to the relocation of innovative activities to India. Most research has argued that European and American lead firms have sought to centralise innovative activities in-house or close to home: their core innovative activities tended to be non-globalised and bound to their home locations due to the importance of tacit knowledge (Chaminade and Vang 2008; D’Costa 2002; Wibe and Narula 2002). However, some recent research on MNCs has identified an increasing tendency to globalise R&D and encourage ‘subsidiary initiatives’ (Asakawa and Som 2008; Krishnan 2006). Similarly, some recent studies focused on global buyers and their outsourcing practices have identified new tendencies of ‘strategy evolution’ with an increased emphasis on the outsourcing of high value, knowledge creating activities and innovative functions (Jensen 2009; Lewin *et al.* 2008; Maskell *et al.* 2007). There have been only limited insights, however, with regard to the types of innovative activities that are outsourced. And little is known about how such innovative processes and functions compare to those in the manufacturing sectors.

Subcontracting linkages between multinational subsidiaries and locally owned firms seem to be rare. Even when multinationals have substantial supplier networks in India, these tend to be coordinated by headquarters in Europe or the USA (Mytelka 2000). However, local firms seem to have benefited from substantial knowledge spillovers from multinationals which contributed to human capital formation in the industry (Patibandla and Petersen 2002). These linkages have primarily been indirect arising from the high levels of labour mobility in the industry: software professionals frequently alternate between employment in MNC subsidiaries and locally owned firms. Fewer studies have addressed the issue of ‘innovation push’ in direct linkages between foreign and locally owned firms in India. While recent literature suggests, as mentioned, that offshore outsourcing has extended from simple services to innovation activities (Engardio and Einhorn 2005; Lynn and Salzman 2007; Maskell *et al.* 2007), the recorded changes on the demand side have not been followed up with systematic assessments of the changes and consequences on the supply side.

The need to redress this gave rise to the research presented in this report. To understand what is going on, we need to understand the neglected issue of lead firms decentralising innovative activity to emerging economies and the resulting interactions between subsidiaries and independent suppliers. The next two chapters present the concepts and methods used in our research.

3 Analytical framework

The question which drives this project is how ODIP emanating from the old powers influences the build-up of innovation capabilities in the rising powers. We seek to understand the dynamics at work. This is not easy because there is no role model we can follow. There are, however, various pockets of literature which we can draw on.

There is a recent literature on the changing geography of innovation (Bruche 2009; Ernst 2009; Fifarek and Veloso 2010; Mudambi 2008) but the organisational decomposition does not play a central role in these studies. The latter is, however, the central concern in the management literature on ‘Open Innovation’ (Chesbrough 2003, 2006; Simard and West 2006). This literature discusses the changing division of labour within and between the old powers, but has little to say about the accumulation of innovation capabilities in the rising powers which – being latecomers – have different starting conditions. This is why we draw on the literature concerned with learning and capability formation in latecomer economies (Ariffin 2000; Bell 2006, 2007; Figueiredo 2006).

These bodies of work are all helpful but what we need most is to understand the connections between them. These connections in turn are not uncharted territory, there is an international business literature concerned with the division of labour and distribution of capabilities between parent firms and subsidiaries in multinational firms (Birkinshaw and Hood 1998; Gerybadze and Reger 1999; Hobday and Rush 2007; Narula and Dunning 2010; Saliola and Zanfei 2009). And there is the value-chain literature that investigates how the relationships between global lead firms and local suppliers influence the build-up of capabilities in the emerging economies (Ernst 2008; Gereffi *et al.* 2005; Schmitz 2007).

Table 3.1 Types of ODIP

Connection of production and innovation \ Intra- and Inter-firm	Internal	External
Loosely connected	**Type 1** Decentralising the R&D Department Setting up Internal Knowledge Communities	**Type 3** Commissioning research from universities or other organisations
Closely connected	**Type 2** Delegating the development of products or processes to subsidiaries Setting up Internal Centres of Excellence	**Type 4** Engaging suppliers of products or services in developing new parts, services or processes

Building on these rich but disparate literatures, Schmitz and Strambach (2009) suggest a framework that puts the organisational decomposition of the innovation process (ODIP) centre stage and provides a basis for integrating the analysis of changes that have hitherto been looked at separately.

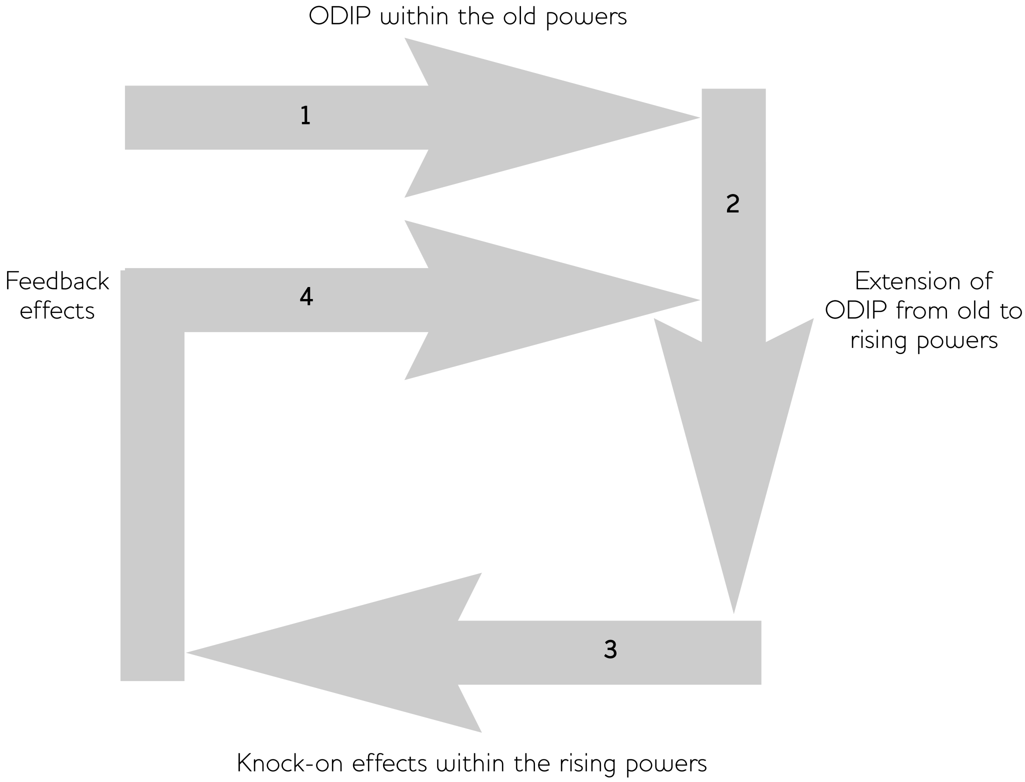
The ODIP framework has two dimensions. The first one refers to decomposition within and between organisations. The distinction is between intra- and inter-organisational – or to keep the language simple: internal and external. The second refers to the extent to which innovation is integrated with production of goods and services. Innovation can be delegated to those who are primarily concerned with knowledge creation and have only a loose connection with the production of goods and services. Or it can be delegated to those who are tightly connected to the production of goods and services and have the latter as their primary function. The former tend to concentrate on research, the latter concentrate more on product and process development; often they include innovation activities bundled into work packages defined in terms of providing a product or service.

The above two dimensions lead to the four different ODIP types identified in Table 3.1. Note that these are ideal types. In practice, there is a continuum between them. Nevertheless, they help us to make sense of the myriad of changes occurring in the real world. As will be shown later – when we apply these categories to 'our sectors' – they need adjustment and qualification, but they help us to identify the organisational changes which are most common and the sequence in which they occur. We also want to see them in conjunction and observe how they unfold within and across the borders of firms and countries.[3]

The types of ODIP, set out in Table 3.1 have been going on within Western Europe and the USA for some time, in particular during the last decade. And as indicated before, there is literature on each of these four types of ODIP. We want

3 For an overview of the literature concerned with particular bits of the decomposition process, see Schmitz and Strambach (2009).

Figure 3.1 ODIP from old to new powers



to find out how this organisational decomposition affects the build-up of innovation activities outside Western Europe and the USA, in particular in the rising powers.

In order to do so, it helps to distinguish between four steps – set out in Figure 3.1. ODIP takes place initially within the old powers (step 1), then extends from the old powers directly to the rising powers (step 2), which produces knock-on effects within the rising powers (step 3), which in turn affects ODIP decisions of the old powers (step 4). We cannot examine each step in equal depth. For some steps, we have strong evidence, for others we have tentative evidence and for some aspects we have no evidence but can offer informed hypotheses.

As mentioned before, there is a wealth of literature on how ODIP unfolds and spreads within the old powers. We do not seek to add to this literature, but focus mainly on the subsequent steps. In examining step 2 – the extension of ODIP from Europe and the USA to India and Brazil – we focus on the delegation of innovative activities to subsidiaries and suppliers. We seek to identify India and Brazil's new *spaces for innovation* – including the nature and boundaries of these spaces.

Step 3 involves examining how ODIP has been replicated within the rising powers. In other words, it examines how the changes in the division of labour – involving rises in the innovation mandate – extend further down the value chain to first and second tier suppliers of products and knowledge services. Most critically, we are interested in how these dynamics affect the build-up of innovation capabilities in Brazil and India. We are particularly interested in how advanced these innovation capabilities are and under what conditions they arise. By including step 4 we explore whether a reverse causality kicks in – higher innovation capabilities in Brazil and India accelerating ODIP decisions in Europe and the USA.

This is an ambitious agenda and the attribution problem makes it impossible to quantify causal connections. We can, however, provide new insights into why and how innovation power is shifting from the old to the new powers and what kind of innovation capabilities are included. The next chapter sets out how we proceeded in the empirical research.

4 Research design and methods

This report examines and compares ODIP and its implications in two sectors. The reasons for comparing a manufacturing and a services sector and the choice of sectors and locations were explained in the introductory chapter. This chapter explains the sampling of firms and the collection of data.

4.1 The selection of firms

Table 4.1 and Table 4.2 show the main 'generic' firm types from which firms were selected for detailed study.

The main differences between the two industries in this respect is that greater value chain segmentation in the auto sector has led to there being multinational suppliers that mirror the geographical pattern of MNC assemblers (Quadros 2009). Hence, there are two types of MNC structures in this industry: MNC assemblers and respective subsidiaries and MNC suppliers and respective subsidiaries. Note also that independent Brazilian suppliers tend to have direct linkages with the Brazilian subsidiaries of MNCs rather than the MNC parent firm in Europe or the USA but there are exceptions (which we have studied). In the software industry, the separation of MNCs into two segments is not feasible. There is less value chain segmentation and the industry itself is constituted of 'specialised suppliers' (Pavitt 1984).

We grouped the firms according to Table 4.1 and Table 4.2, but we did not give equal emphasis to all of these types of firms in the two sector studies. The criterion for selecting firms was purposeful sampling (Yin 2002). The logic of this

Table 4.1 Firm types in the auto case

	Intra-firm value chain		Inter-firm value chain
Europe/USA	MNC Auto Assembler	MNC Supplier	Global Auto Assembler or Component Supplier
Brazil	MNC Assembler Subsidiary	MNC Supplier Subsidiary	Independent OEM Supplier

Table 4.2 Firm types in the software case

	Intra-firm value chain	Inter-firm value chain
Europe/USA	MNC Software Producer	Global Software Customer
India	MNC Software Subsidiary	Independent Software Supplier

type of sampling was to select information-rich cases that could reveal insights about the general decomposition of innovation, illuminate different types and aspects of ODIP, and reveal insights with regard to the possible implications.

In the auto case study, we examined firms of the following types:

- Multinational assemblers' subsidiaries in Brazil
- Multinational OEM suppliers' subsidiaries in Brazil
- Local OEM suppliers.

In the software case study, we examined firms of the following types:

- Multinational software producers' subsidiaries in Bangalore
- Global buyers sourcing software services from India
- Local export oriented software suppliers.

The samples in the auto and software cases are shown in Table 4.3 and 4.4 respectively. We gave preference to firms headquartered in Germany in order to be able to check and trace connections with colleagues who had collected information in Germany.

Table 4.3 Firm sample – auto case

Type	No	Description
Multinational assemblers' subsidiaries in Brazil	2	One North American car assembler with advanced relocation policy: General Motors (GM); One German truck assembler: Volkswagen Trucks and Buses (VW T&B)
Multinational OEM suppliers' subsidiaries in Brazil	4	Three German systems/component global producers with a strong profile in Brazil (supplying the above assemblers): Robert Bosch (fuel systems division), Mahle (engine components division), ZF Sachs (clutch linings and friction materials division); One North American systems/component supplier (which is a 'risk-sharing partner' to VW T&B): ArvinMeritor
Local OEM suppliers	8	Four Brazilian companies, which are suppliers to at least one of the foreign firms: Sifco, Sabó, Arteb, and Fras-le; two recently established suppliers stemming from the ArvinMeritor and Brazilian Randon group partnership and also suppliers to VW T&B: Master and Suspensys; One supplier established in the 1980s in the engineering industry which has diversified into auto-parts: Lupatech; One is a small supplier which has developed with support from Bosch: Letande

Note: Further details about these firms are given in Quadros (2009).

Table 4.4 Firm sample – software case

Type	No	Description
Multinational companies (MNCs) with subsidiaries in Bangalore	6	Four German MNCs: Robert Bosch Engineering and Business Solutions (RBEI); Siemens Information Systems Limited (SISL), Siemens Communications Systems (SCS) and SAP Labs India. Two non-German MNCs which acquired 'local' firms in our sample during the course of our research: Nokia/Symbian and HP/EDS.
Global buyers sourcing software services from India	3	Three global buyers that initiated substantial outsourcing projects/relationships with software suppliers in Bangalore: Nokia, Passalong Networks, and Volvo IT.
Independent software Suppliers in India	8	Four multi-domain software suppliers (Infosys, MindTree, MphasiS and Wipro), two suppliers of outsourced product development services (Aztecsoft [now MindTree] and Aditi), and two suppliers of engineering services (Sasken) and testing services (RelQ, now HP).

Note: The sample includes lead firms interviewed jointly by Rasmus Lema, Philipp Oswald and Simone Strambach as well as firms interviewed by Lema for his doctoral research (Lema 2009b). Complementary information about the MNC firms is available in Oswald (2008). The three global buyers were chosen for this paper as indicative of a larger buyer sampled examined in-depth elsewhere (Lema 2010). The analysis of the software suppliers draws on Lema (2009b) but does not include supplier firms that are focused on made-in-India (MIP) packaged software products.

4.2 Data collection

The data for this research comes from the usual secondary sources and from interviews carried out in India and Brazil (Quadros 2009 and Lema 2009b). We also draw on interviews and correspondence with buyers/lead firms in OECD countries and on data on the German auto and software industries collected mainly by our colleagues Philipp Oswald (2008) and Simone Strambach (Strambach and Klement 2010; Strambach and Dieterich 2011). Whenever possible we seek to bring together the view from above (the lead firm perspective) and the view from below (the supplier perspective), but our data on the latter is stronger than on the former.

The interviews concentrated on innovation events, which were important for the evolution of the firm and required strong innovation effort in Brazil or India. Innovation events are milestones at which the firm is challenged to demonstrate its maximum capabilities. Examining several innovation events makes it possible to assess the firm's progress in terms of building up innovation capabilities.

Interviews were based on semi-structured questionnaires and sought to assess the technical and commercial ties between customers/parent firms and suppliers and the firms' ability to rise to the challenges. A combination of in-depth interviews and site observations were used as a means to collect first-hand evidence. We interviewed senior managers with direct responsibilities for aspects of innovation in the firms. Examples include senior engineering managers, product centre managers or supply chain managers, senior managers for particular product and/or country markets and similar managers in suppliers of equipment or knowledge-intensive services. These respondents were particularly important as sources of detailed information about the organisational structure of the innovation process (the different elements of the process, how they are divided across enterprises and how they are coordinated), and how this had changed over time. The information obtained in interviews was complemented with information from company reports, marketing material, websites and press reports.

Given the difficulty of obtaining reliable primary information for this analysis of change, the timeframe was limited to five years. However, in each case, this primary analysis of change was embedded in the use of secondary material throwing supplementary light on longer periods of change.

5 Innovation activity in the Brazilian auto and Indian software industries

The enormous production capacity of the Brazilian motor industry is well-known, but there is less knowledge about its engineering and design capabilities. Similarly, the fast growth of the Indian software industry is widely acknowledged, but whether this contains significant innovation is unclear. This chapter seeks to answer this question for both industries. Before examining how ODIP contributed to the build-up of innovation capabilities, it helps to show the existence of such capabilities. This is particularly important since most of the literature – summarised in chapter 2 – is sceptical in this respect.

The chapter is based on both secondary and primary sources. It starts by drawing on secondary data to examine conventional innovation indicators – R&D spending and patent filings – as a backdrop for the further analysis. It then zooms in on the firms in our samples, examining the changes in their activities and the capabilities which they demonstrated in the sampled innovation events.

5.1 Conventional indicators

What do the conventional indicators tell us about the breakthrough to advanced innovation capability in the Brazilian auto and Indian software industries? This brief subsection examines the available evidence.

5.1.1 Brazilian automotive industry

In recent years, the R&D intensity of the automobile industry (including automakers and auto-parts suppliers) has increased faster than in the Brazilian manufacturing industry as a whole. As shown in Table 5.1, between 2000 and 2008, the auto industry spending on R&D grew by more than six times, reaching R$3.4 billion in 2008 (equivalent to approximately US$ 2 billion in 2010). R&D spending by the Brazilian manufacturing industry as a whole grew approximately three times in the same period. In 2008, the technological intensity, that is, the ratio of R&D expenses to net sales in the automotive industry was 1.65 per cent (up from 1 per cent in 2000). The share of the auto industry R&D spending in total industrial R&D spending more than doubled from 2000 to 2008, accounting for approximately one

Table 5.1 R&D spending in the Brazilian automobile and manufacturing industries

	2000	2003	2005	2008
Automotive industry				
Total R&D (R$ million)	549	1,363	1,900	3,384
Total R&D/sales (%)	1	1.6	1.4	1,65
Manufacturing industry				
Total R&D (R$ million)	4.336	5.739	7.979	12.386
Total R&D/sales (%)	0.8	0.6	0.7	0,7
R&D auto/ R&D total industry (%)	13	26	24	27

Source: Quadros (2009) and PINTEC/IBGE (Brazilian Innovation Survey).
Note: Total R&D spending comprises external R&D and outsourced R&D.

quarter of the total R&D in the manufacturing industry. However, it is important to add that assemblers account for 80 per cent of the spending on R&D.

Arguably, the R&D activity measured by this innovation survey primarily reflects product and process development (D rather than R). Furthermore, these numbers primarily express the expansion of product development units in the assemblers rather than in OEM component suppliers. Indeed, the ratio of R&D personnel with university education/total employment in the Brazilian auto-parts industry, in 2008, was 0.96 per cent which was above the average ratio for the Brazilian manufacturing industry (0.62 per cent), but substantially below the 4 per cent ratio for the assemblers segment of the automobile industry. However, the fieldwork data – see Table 5.2 – indicate that most component suppliers in our sample (both foreign and locally owned) have ratios of R&D staff to total staff that are substantially higher than those of the Brazilian auto-parts industry overall.

With regard to output indicators, the patent data indicates that, in the group of 12 supplier firms investigated, the majority of firms report patenting activity – irrespective of ownership being foreign or national. Table 5.3 shows that eight out of the 12 sample suppliers have undertaken patenting activity in recent years.

Table 5.2 R&D staff with university education in sample firms, 2006/7

Firm	R&D Staff	Total staff	Ratio
ArvinMeritor	24	1.000	2.4%
Bosch	250	8.250	3%
Mahle Metal Leve	150	8.000	1.8%
ZF Sachs	16	-	-
Arteb	72	1.200	6.0%
Lupatech/Steelinject	14	608	2.3%
Sabó	65	3.316	2%
Fras-le	30	2.000	1.5%
Freios Master	11	600	1.8%
Letande	9	272	3.3%
Sifco	20	2.300	0.9%
Suspensys	22	2.000	1.1%

Source: Interviews.

Table 5.3 Sample firms: patents submitted and granted in Brazil

Firm	Ownership	Patents submitted 2001/2003	Patents submitted 2003/2005	Patents granted 1994/2003
Arteb	Brazilian	7	—	1
ArvinMeritor	Foreign	21	9	2
Bosch	Foreign	3	7	1
Freios Master	Brazilian	—	1	—
Lupatech	Brazilian	1	2	2
Mahle Metal Leve	Foreign	1	—	7
Sabó	Brazilian	5	7	17
ZF Sachs	Foreign	—	—	2
Total		41	26	36

Source: INPI (Brazilian National Patent Office). Note that this is a special tabulation produced for the IBI Project (Brazilian Innovation Index). There is an overlap between the two time intervals considered in patent submission, as the year 2003 is counted in both. Only inventions made by Brazilian nationals have been considered in this special INPI tabulation, even if the patent holder is a multinational corporation.

5.1.2 Indian software industry

Conventional R&D indicators for the Indian software industry are notoriously scarce. Table 5.4 shows that more than 60 per cent of the firms in the Indian software service sector engaged in R&D activities in 2010.[4] This survey covered headquarters of Indian MNCs, subsidiaries of foreign MNCs in India and standalone firms acting as independent suppliers.[5] The table shows that MNC headquarters in India had the highest propensity to undertake R&D (78 per cent reporting in-house R&D units). This is marginally higher than for the MNC subsidiaries (it was 75 per cent). In terms of Indian standalone firms without global operations (other than exports), 46 per cent had R&D departments. Data on R&D intensity – i.e. the degree to which R&D departments incur real expenditures – is slightly older. A survey of 119 software firms conducted in 2004 found that the R&D costs as a percentage of total costs in Indian software services firms were 3.5 per cent, but it was 15 per cent in software product firms (Gregory *et al.* 2009: Table 6.4). We do not have more recent data but it thus seems that average R&D intensity in the software industry was low compared to the Brazilian auto industry. This is partly explained by the overall service focus (rather than software product focus) of the Indian software industry, which reduces the need for R&D investment (Bhatnagar 2006: 73).

Moreover, Table 5.5 shows that although Indian MNC firms invest most in R&D, most patenting activity is undertaken by foreign firms. Nevertheless, some Indian-owned software firms are now beginning to file for patents as there is increasing

4 Drawing on a NASSCOM database, the survey was undertaken in 2010 in eight Indian cities with substantial software service activity. The survey resulted in a sample of 325 completed questionnaires, which was a response rate of 24 per cent. The 325 firms in the survey equate to 23.85 to per cent of firms registered in the NASSCOM database.

5 Note that our study has not made the distinction between Indian MNCs and standalone firms, although several of the sampled firms would fall under the former category as per their overseas investments (see section 8.1.2)

Table 5.4 Existence of R&D activity in software firms in India in 2009/10 (%)

	Standalone	Subsidiary of MNCs	Headquarter of MNCs	Total
R&D No	53.89	25.47	22	39.63
R&D Yes	46.11	74.53	78	60.37
Total	100	100	100	100 (n=325 firms)

Source: Joseph and Abraham (2011).

Table 5.5 Patenting activities of selected leading software firms in India

Company		2004–05		2005–06	
		Filed	Granted	Filed	Granted
Adobe	Foreign	10	-	32*	-
Cadence	Foreign	1	5	-	-
Flextronics	Foreign	2	1	4	1
Freescale	Foreign	10	-	16	4
i-flex	Indian	1	-	1	-
Infosys **	Indian	-	-	20	-
Microsoft	Foreign	40	-	70	-
MindTree **	Indian	1	-	2	-
Ramco	Indian	16	-	16	-
Sasken **	Indian	5	-	5	5
ST Micro	Foreign	62	32	37	14
Subex	Indian	-	-	2	-
Symantec	Foreign	47	43	57	16
TCS	Indian	16	5	13	4
Texas Instruments	Foreign	35	10	-	-

Source: Adapted from Arora (2006), based on DQ estimates. All figures of foreign firms represent US patents filed by the Indian R&D facilities of these MNCs in all fields, not just software patents.
*Adobe's patents represent the total number of patents filed since start of India operations.
** Sample firms included in this study.

scope for filing patents in the software services. This is what the evidence from sample firms suggests: Infosys filed 79 patents to USPTO and the Indian patent office in 2008, Wipro filed for 17 patents in 2007, Sasken has been granted an accumulated 20 patents and MindTree has been granted 12 at the time of writing.[6]

5.1.3 Insights and limitations

The secondary data is sketchy – particularly in the case of India – but overall, the conventional indicators suggest that R&D and patenting activities are growing in both industries, albeit from a small base. These quantitative indicators provide some insights but they are insufficient to assess the innovation capabilities in the selected industries. These standard metrics reflect patterns of innovation only in certain kinds of sectors (NESTA 2007) and – as will be shown – the chosen sector/country sites innovate in ways which are only partially reflected in these metrics. In both cases,

6 This information was drawn from annual reports.

significant innovation occurred outside the R&D department. In order to capture this and examine how deep it goes, one needs to rely on qualitative case study material. This is presented next.

5.2 Trajectories and value chain tasks

In order to understand and compare the level of innovation activities in the sample firms, it is useful to distinguish between high-level 'systemic' development and low-level 'applied' development. Strambach (2009) has suggested these concepts for the analysis of the German software and auto industry and we have adapted them for our cases – see Figure 5.1.

This conceptual approach helps to capture broad changes over time and to do this in a comparative way. The substance behind Figure 5.1 is complex but the overall idea is simple: firms able to carry out activities on the left side have reached a higher level of capability than those firms that can 'only' carry out activities shown on the right side. The groupings of activities can be contested – and different groupings would be useful for different industries and different objectives[7] – but for our purposes, Figure 5.1 is very helpful. It brings out that in both industries, the majority of the sampled firms have been able to make the shift from low-level 'applied' development to high-level 'systemic' development.[8] This requires elaboration.

In order to assess the 'level' firms had reached at the time of the fieldwork, we focused on the most significant innovation events. The idea was to approximate firms' capability levels by identifying product and process events (milestones) which were particularly challenging for the sampled firms. We examined these firms' (subsidiaries and suppliers) ability to cope with the 'problem' (in process or products) put to them by the lead firms (parent firms or buyers).[9] As discussed, lead firms have tended to keep for themselves basic research and the high-level 'systemic' development activities while farming out downstream tasks. We re-examined this, comparing reality in the 2000s with reality in the 1990s reported in previous research on the Brazilian auto industry (Cassiolato *et al.* 2001; Quadros 2004) and the Indian software industry (D'Costa 2002; Lema 2009a). We focused on what sampled firms 'could do' – as indicated by actual activity in the innovation events.

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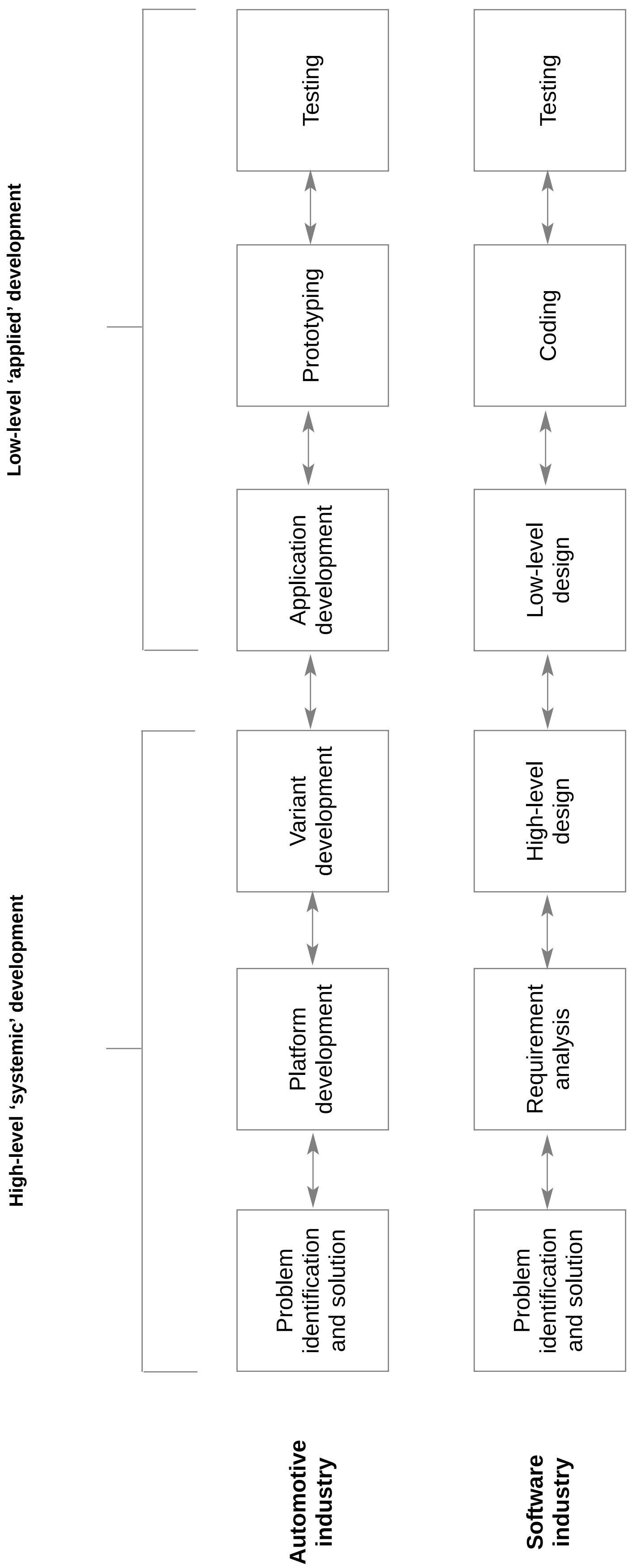
7 For example, a comparison between firms in Germany and Brazil would need to unpack the category 'problem identification and solution' since it includes research activities of different degrees of complexity.

8 Systematic comparison across the auto and software sectors – using the categories of 'advanced', 'intermediate' and 'basic' innovation capabilities proposed by Bell and Pavitt (1995) and Ariffin and Figueiredo (2006) – proved impossible because innovation in manufacturing and services differ substantially. For our purposes, the categories proposed in Figure 5.1 proved more useful and straightforward. While applicability of the Bell and Pavitt framework was more difficult in the case of software. For our purposes, the categories proposed in Figure 5.1 proved more useful and straightforward. For the application of the Bell and Pavitt framework in the Brazilian auto case, see Quadros (2009).

9 The figure describes processes that apply – in principle – to any development project, whether it is concerned with a component or an entire system. We maintain this focus on the *immediate* user's problem (even if the buying company itself is a subsystem supplier in intermediate markets) in order to avoid the problem of modularity and different levels of analysis.

Figure 5.1 Product and system development processes



Source: Adapted from Strambach (2009) and Oswald (2008). Note that formal research may support any of the steps in the processes. Problem identification and solution can be research-based in both sectors, but this is not necessarily the case.

5.2.1 Brazilian automotive industry

Until the late 1990s, product development activities by automakers in Brazil had concentrated on adapting foreign platforms to local conditions (tropicalisation) and, to a lesser extent, on developing local models – or derivative vehicles – from global platforms to suit local demand requirements. After the 1990s, some assemblers went beyond this level by accumulating capabilities in designing and engineering complete derivative vehicles (Consoni and Quadros 2006). A 'complete derivative vehicle' corresponds to more than a regular derivative and less than a completely new platform. Usually derivatives are built on the hatch model of a vehicle platform in order to offer options in the same product 'family': saloons, wagons and light pick-ups. A completely new derivative bears little or no resemblance to the original platform on which it is built. It is an entirely new design and body on top of a known mechanical platform, thus including various new items. In Brazil, models like GM Meriva, VW Fox and the new GM Agile are complete derivatives. Indeed, the idea of complete derivatives somehow denies or contradicts the concept of the global platform, since the level of change it implies, including major changes in the body and thus in body dynamics, requires a considerable amount of re-engineering and re-validation that requires substantial innovation.[10]

The changes over time apply to both multinational and local firms. Starting with the former, three out of four sampled multinational OEM suppliers have established themselves in Brazil through acquisitions (brown field investment). This applies to ArvinMeritor (acquisition of Rockwell/ Braseixos, in the 1950s), Mahle (acquisition of Metal Leve, in the 1990s) and ZF Sachs (acquisition of BorgWarner, in the 1980s). The trajectories of these firms show that these units have upgraded their capabilities both before and after foreign ownership. Bosch has also undergone a rapid transformation in capability profiles between the early 1990s and the late 2000s. They shifted from application development to problem identification over a 15–20 year period. The exception to this is Metal Leve (now Mahle Metal Leve), that already had advanced capabilities in the early 1990s.

The capability transformation of local OEMs is similar to that of the MNC segment, although it is not entirely matched. In the early 1990s, most local firms in the sample engaged in application development. Sabó had already mastered variant development. However, most local firms (all but Sifco and Suspensys) were able to progress to high-level systemic development, albeit to different degrees. As will be discussed, this advance is partly explained by the opportunity to participate in co-design with their customers (see section 7.2).

In order to bring out the full progress made by some of these firms, one would need to add the category of 'Research' to Figure 5.1. Mahle, ZF Sachs and Sabó have been able to create and introduce product innovations that are based on substantial research. This advance into research is reflected in Table 5.7 and detailed in Quadros (2009).

The key point concerning the advances made by sampled Brazilian companies can be made by contrasting them with their counterparts in Germany. In Brazil,

10 In the case of the GM Meriva, the new vehicle is a hybrid, because some of its components are common to the Corsa platform and others to the Astra platform.

research tends to be subsumed under New Product Development and focused on specific problems as and when they arise.[11] In contrast, the German companies have corporate research centres working systematically on broader challenges (Strambach 2009).

5.2.2 Indian software industry

Most of the MNCs in the Indian sample have established themselves in Bangalore through green-field foreign direct investment (FDI). SAP Labs, Robert Bosch Engineering and Business Solutions Limited (RBEI), Siemens Information Systems Limited (SISL) and Siemens Communication Systems (SCS) were all established in Bangalore during the 1990s. These subsidiaries have undergone a rapid transition in a relatively short time period. The case of SAP Labs is illustrative. When the subsidiary was first established in 1997, work was assigned on a 'black-box' basis, meaning that the headquartering Waldorf, Germany, undertook all elements of high-level design whereas the Lab in Bangalore was focused on coding and testing to tight specification, without any in-depth understanding of the context in which the code was being used. In 2000, SAP Labs Bangalore started with localisation of existing products – thus moving into requirement analysis and design – even though the high-level architecture was defined in Germany. Today the independent new product development of SAP Labs Bangalore has a global reach and the number of patents that SAP Bangalore files has gone up year by year, and the number of patents per employee filed from India is now twice that of patents filed from Waldorf. While this is mirrored by RBEI and, to some extent SCS, SISL has progressed less. Symbian India entered the market through a phased acquisition, in a build-operate-transfer agreement with a local firm. Before and after the takeover the unit has moved from maintenance, over co-development to independent development.

The dramatic growth that occurred in the 1990s – mainly in the second half – encouraged a large number of local suppliers to enter the market, including most of those discussed in our sample. However, the largest firms, Infosys and Wipro, started their (customised) software development activities in the early 1980s. During the 1990s, these firms specialised in the provision of programming services (coding and testing) to relatively tight specifications. They were soon joined by incumbents such as Kshema, MindTree and RelQ (a dedicated software testing firm), all of which were spinoffs from larger software service houses. Firms such as Sasken developed solutions for the personal computer market in the form of 'embedded software'. They were already undertaking innovative activities – the in-house development of reusable and proprietary solutions – but they were generally not involved in high-level design activities; the latter were undertaken by customers who needed to ensure operability with other parts of their systems. At the same time, there were a number of smaller startups – Aditi and Aztecsoft – that shared the dream of bringing made-in-India software products to the world market. In this sense, they were all working in the field of high-level software design. However, none of these enjoyed success due to different reasons, including inadequate (or misguided) problem identification and requirement

11 Except for the Mahle Metal Leve case which has a formal mandate for technology research.

analysis, sometimes poor quality of the products, and limited marketing resources. In this sense their efforts at leapfrogging into high-level system development was premature.[12] Furthermore, some of them came under severe financial pressure as they had addressed the US internet and related technology market which crashed just after the turn of the twenty-first century.

The 2001 slowdown in the IT sector was an inflection point for all of the sampled firms as it forced firms to rethink their markets, business strategies and technological competence profiles. In 2001, the management team in Infosys was in intense strategic deliberations concerning how the firm should respond to the crisis. According to one of the company founders, the leadership group realised that the firm had to enter the 'creamy layer' that was occupied by brand-name consultancy houses.

> *We realised that we had to compete with, say, IBM and Accenture. We don't want to supply to IBM and Accenture who will take away the cream. We need to enter the creamy layer. If your technological edge vanishes, then who do you compete with? At that time, it was a question of our existence.*
> (Infosys interviewee, 28 November 2006)

The new strategy was to develop the company's consulting business, helping the customers to meet business challenges through improvements to business processes. This meant that they would need to take part in the processes that define and transform customers' or end-users' IT and software systems. Since then, the firm has had substantial success in this field, supported by important internal innovations. In general, business software services firms – such as Infosys, MindTree, Wipro, RelQ – have refocused their lines of business and developed new domain competencies. They have developed domain expertise and frontline capabilities, and they are no longer only in programming mode, even though the labour intensive 'execution' element of business remains important. Crucially, they participate in high-level co-design, sometimes including requirement analysis and even problem identification. In contrast, RelQ, now owned by HP, took the 'functional deepening' route, specialising in testing. Carving out such spaces as separate and independent activity allowed these companies to establish new and innovative processes.[13] Sasken has re-oriented towards the telecommunication markets and has developed systems integration competencies, as is evident, for example, in the development of integrated multimedia solutions for handset manufacturers. The software products startups have either taken the services route, now providing offshore product development services including high-level design services (Aditi and Aztecsoft – now owned by MindTree) or have reoriented their strategies in the local and global markets.

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12 These problems were pointed out by senior managers in these firms.

13 While the provision of standard independent testing services (ITS) is a routine-based activity, RelQ (and incumbents in the ITS field) have accumulated the critical mass of specialised expertise in this area that enabled them to enter the field of test consulting. Indian ITS firms increasingly engage in testing management and consulting services such as test and quality assurance strategy and certifications.

Table 5.6 Evolution of capabilities in sample firms

	Brazilian automotive industry	Indian software industry
1990s	Majority of firms focused on application development. Only two firms with proven capabilities in high-level 'systemic' development (Metal Leve and Sabó)	Majority of firms focused on coding, testing and other tasks in low-level 'applied' development. Only two firms with proven capabilities in high-level design (Aditi and Aztecsoft)
2000s	Majority of firms have proven capabilities in problem identification and solutions. Only two firms without proven capabilities in high-level 'systemic' development (Sifco and Suspensys)	Majority of firms have proven capabilities in high-level design including problem identification (Infosys Wipro, RBEI and SAP). Only two firms with capabilities confined within low-level design stage (SISL, RelQ)

5.2.3 Summary and examples

To summarise, an inter-temporal comparison shows that over the last ten to 15 years both multinational and local firms have progressed substantially even though not all to the same extent. The majority of the sample firms have progressed from low-level 'applied' to high-level 'systemic' capabilities in both the Brazilian automotive and the Indian software industry (Table 5.6).

Specifying which of the sectors had achieved a higher level would, however, be difficult. The Brazilian auto firms have more examples of research-based problem-solving strategies; but the software firms have progressed over a shorter period of time. Pushing this cross-sector comparison further would be un-productive because there are inherent sector-specific and country-specific differences which determine what firms can and cannot do. More important for our purposes is the inclusion of hidden innovation in the assessment of the capabilities.

Table 5.7 gives for both sectors ten examples of innovation resulting from high-level capabilities. For the purposes of illustration, some of these examples are worth elaborating on further: Sabó, one of the largest (and oldest) Brazilian auto-parts suppliers, developed an integrated oil sealing system and sensor (IOSS) for the new VW Polo, launched in 2002. Over 2.5 years, 20 engineers in Sabó led the development of the sensor in cooperation with a French developer of sensor technology, enabling electronically controlled fuel consumption and emission measurement in the Polo, and later in other vehicles. Similarly, the Brazilian subsidiary of Bosch developed a flex-fuelling system for passenger cars. This system was initially aimed at the local market, but it 'went global' as biofuels became increasingly important worldwide. The development of this flex solution – working with petrol, ethanol or natural gas – has placed the Brazilian subsidiary in a strategic position within Bosch and deemed it a centre of excellence in flex-fuelling systems. R&D is relatively important for capability expansion in the auto-parts business. Seven out of 12 interviewed suppliers used substantial R&D for their innovations; three of them were Brazilian owned (Arteb, Lupatech and Sabó).

Although R&D is generally less important in the software supply base, some suppliers relied on substantial R&D inputs. For instance, Infosys Technologies, one of India's largest software developers, created InFlux, a proprietary framework

Table 5.7 Innovation events (milestones) reflecting capabilities in high-level systemic design

Brazilian automotive industry	Indian software industry
• **Arteb**: Top Colour Enamel • **ArvinMeritor**: MS-113Tractive Axle • **Bosch**: Flex power-train fuelling system • **Fras-le**: PD-981Non-steel (brake pad) • **Letande**: Injected connectors and Cables for Flex-fuel Pumps • **Lupatech**: PADS – Plasma-assisted debinding and sintering process • **Mahle**: PVD-based Chrome Piston Rings • **Master**: Brake system HD, 325x100/120mm Tube • **Sabó**: IOSS – Integrated Oil-sealing System with Sensor • **ZF Sachs**: Sachs 188 and Sachs 620 (non-leaded clutch linings)	• **Aditi** – Online Digital Media Distribution Platform • **Aztecsoft**: ETL Tool for Data warehousing • **HP/EDS India** – Billing and operations • support solution • **Infosys** – InFlux tool for mapping business • processes • **MindTree** – Partner CRM sales tool system • **SAP Labs India** – SAP Business ByDesign • **Sasken** – Multimedia Subsystem • **Symbian India** – PIPS Posix library solution for software migration • **Wipro**: Cross-applicable Ultra wideband solution • **Wipro** – Lean Software Framework

Source: Authors' fieldwork: Lema (2009b) and Quadros (2009). Note: Listed alphabetically according to ownership (at time of fieldwork).

for business process modelling (BPM). SETLabs, the primary R&D unit in Infosys, deployed nine engineers, including several PhDs, for 12 months in the effort to develop the framework in 2001. Today this solution supports Infosys' foray into the global IT consulting space. It aims to capture 'business requirements' and aids the translation of these into technical specifications. It has been used in in-house consulting projects and licensed out to leading IT houses in OECD countries. MindTree Consulting, a startup established in 1999, engaged in the end-to-end development of a sales tools system for aftermarket trucks, for a leading European auto manufacturer. It participated in requirement-level system definition and was responsible for the overall design and subsequent coding of the system. Both of these examples illustrate that software suppliers participated in the architectural definition of buyers' systems and products.

5.3 Conclusion

The literature on the Brazilian auto and Indian software industries tend to be pessimistic regarding their innovative capabilities (see section 2). This section, drawing on our own primary research, gives a more optimistic picture of the sampled firms. Some segments of these industries have innovation capabilities of a significant depth.

The R&D intensity in the Brazilian auto industry is significantly higher than in Brazilian manufacturing on average. While much of this is still concentrated in assemblers, all of the sampled suppliers have begun to carry out substantial R&D and some have patented their innovations. The case material shows that this also applies to suppliers owned by Brazilian nationals. This finding runs counter to literature which suggests that Brazilian-owned suppliers had only a minor or no role in design and engineering activities (Salerno *et al.* 2003). Furthermore, the findings refute the expectation that the national auto-parts supply industry would be crowded out of knowledge intensive activities, following the de-nationalisation wave of the 1990s, which affected important brands like Metal Leve, Cofap and Varga. It is interesting to note that less known brands such as Lupatech and Randon, together with surviving brands like Sabó and Arteb have increased their innovation capabilities.

Formal R&D seems to play a lesser role in the Indian software industry, but the data remains sketchy. Case studies show that the larger firms, in particular, are beginning to establish substantial internal research departments. Patenting is also increasing in importance for selected firms, some of which have accumulated impressive patent portfolios. However, input and output indicators do not capture the full extent of capability accumulation in the sampled firms. The interview-based analysis of firm trajectories indicated a major transformation over a ten-year period. They are increasing their share of knowledge intensive tasks in the software value chains and have carried out high-level ‘systemic’ design tasks in the innovation events we analysed. The findings qualify the existing literature (Arora *et al.* 2008; D’Costa 2009; Dossani 2006) by showing that an important segment of innovation-active firms have emerged in the industry over the last ten years.

The analysis provided here does not allow generalisation to the whole industry. Our samples are not representative, but designed purposefully to maximise the insights into the global and national reorganisation of innovation. Undoubtedly, there are many ‘non-innovators’ in both the Brazilian auto-parts and Indian software Industry. On the other hand, our samples do not constitute the only innovation-active firms. Less known brands like DHB, Aethra, Metagal, Pematech and Zen in Brazil could possibly be included in this group and deserve further investigation. In India, the sample was limited to firms located in Bangalore, and many more firms could have been identified both within and outside Bangalore. There is no reason to believe that the sampled firms are significantly more innovative than other Indian firms such as Ittiam, L&T Infotech, Satyam Computer Services, Subex Systems, Tata Consultancy Services and others. Patent data and R&D data can confirm this but – as stressed throughout this paper – the full extent and depth of capabilities only becomes apparent once we include those innovation activities which are outside the R&D department.

6 Lead firms and the organisational decomposition of innovation

The previous chapter has shown that substantial innovation capabilities have been built up in the rising powers. This chapter examines how the old powers have contributed to this build-up. It concentrates on the European and American lead firms in the auto and software firms, asks how they have reorganised the innovation process and how this has affected their subsidiaries and suppliers in Brazil and India. The main questions driving this chapter are: what types of ODIP did the lead firms adopt and what opportunity spaces have opened up for the subsidiaries and suppliers in Brazil and India.

Section 6.1 takes a lead-firm view. Drawing on the insights from case study firms (and secondary literature where relevant), we sketch out the key changes in innovation practices among lead firms in the respective industries. Sections 6.2

and 6.3 then examine what the (cross-border) ODIP means for new innovation spaces in Brazil and India respectively. Section 6.4 examines the limits and boundaries of this process and section 6.5 summarises the main findings.

6.1 Changes in the innovation process and lead-firm restructuring

6.1.1 Automotive industry

The global automotive industry is second only to the pharmaceutical industry in total volume of R&D expenditure ($ 55.1 billion, in 2006), while four out of the top ten global firms ranked by R&D investment are automotive companies (Moavenzadeh 2008). The globalisation of innovation in the automotive industry is evident from the study of German lead firms. As observed by Strambach (2009), the automotive industry is a multi-technology industry, drawing on a variety of knowledge domains, including most physics and chemistry-based engineering disciplines and a booming field of automotive ICT. It is increasingly difficult to master all these fields of knowledge, and the capability to integrate different competences and technologies is critical for innovation. It is this increasing complexity of innovation that drives the tendencies to include more external actors and foreign subsidiary units in the development of new products and processes.

However, in spite of increasing technology complexity, New Product Development (NPD) accounts for an overwhelming share of R&D investment *vis-à-vis* research on new technology exploration.[14] Moreover, while most innovative activities remain concentrated in the old powers, increasing importance is given to innovation in the rising powers, in particular China and Brazil. This is where the markets are growing; this is where investment in new product development is rising fast.

We found that Brazil's new role in the corporate networks takes two main forms. First, some global auto firms are decentralising the R&D department by setting up formal research units. This seems particularly important in the case of some global OEM suppliers. Mahle and ZF Sachs, two German suppliers, have both extended their corporate R&D networks with R&D units in São Paulo. Secondly, and most frequently, MNCs (assemblers and OEMs) are now delegating the development of new products to subsidiaries and they are setting up competence centres for this purpose. Some subsidiaries have the mandate for end-to-end development of new vehicles, systems and components for the Brazilian and the global market.

6.1.2 Software industry

Lead firms in the global software industry have also reorganised their innovation processes. Multinational firms have established R&D facilities in countries such as India and Israel, even if such investments were only made after rapid growth in indigenous firms (Giarratana *et al.* 2005). Of equal importance is the role of global buyers that do not establish subsidiaries, but engage in cross-border trade. Their interactions with Indian suppliers have become much more knowledge intensive

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14 According to a study by the US National Academy of Engineering, which was based on primary information, the three US companies which provided data revealed that they spent less than 10 per cent on basic or applied research and more than 90 per cent on product and process development (Moavenzadeh 2008: 69).

over time as they have evolved towards innovation outsourcing (Jensen 2009; Lema 2009b). This tendency towards cross-border innovation sourcing is also observed in the study of German software firms. Oswald (2008: 35) found that software firms in Baden-Wuertemberg had gone through distinct phases in terms of offshored content: the tasks outsourced to countries such as India and Malaysia evolved over low-level design, architectural design to global product responsibility. In tandem with this evolution in outsourced work, the software firms in Germany re-focused their in-house work. They increasingly focused on higher value tasks which depend heavily on vertical knowledge and on experience-based knowledge of the end-users' business processes (Oswald 2008). Such knowledge was generated in long-term relationships and required close interaction.

Similarly, Lema (2010) found that some software firms in the USA and Europe were changing their sourcing behaviour in important ways, increasingly creating opportunities for innovation by suppliers in India. This was linked to restructuring in lead-firm organisations. Innovation was often decentralised within the firm, thus affecting the business units with outsourcing/offshore engagements in India. Core staff in the lead firms in the software services space were increasingly drawn into the innovation process of end-users and typically focused on non-technical elements of innovation. This created an internal vacuum that increased the space for developing new technical innovative capability in supplier firms.

6.2 Automotive industry: ODIP and new spaces in Brazil

The scope of lead firms' activities in the Brazilian automotive industry has risen steadily over the past 20 years, from adaptation to complete vehicle design (Quadros and Consoni 2009; Quadros 2009). To varying degrees, this holds true for the four major lead assemblers, General Motors (GM), Volkswagen (VW), Fiat and Ford. Today, these subsidiaries have robust product development capabilities and distinct product development mandates. Only the Japanese assemblers (Toyota and Honda) stick to the policy of keeping product development and adaptation entirely centralised in the Japanese or North American product development units.

New innovation mandates for Brazil are prominent also in the MNC OEM supplier segment. Table 6.1 shows the ODIP patterns of the sampled multinationals. External decomposition directly from German or American headquarters directly to Brazilian suppliers happens but remains rare.[15] More common is the decomposition internal to the firm– at least in the first instance.[16] It is concentrated on Type 1 and Type 2, using the categorisation proposed in Table 3.1. These are discussed in turn.

6.2.1 Type 1 – Decentralising the R&D department with a substantial unit in Brazil

Only two firms practice ODIP type 1. The Brazilian subsidiaries of German auto-parts producers ZF Sachs and Mahle host R&D units which carry out

15 Lupatech and Arteb have worked on innovation projects for GM-USA and Sabó has worked for VW Germany.

16 In the second instance, ODIP becomes external. This is discussed in section 7.

Table 6.1 Types of ODIP – automotive lead firms

	Intra-firm		Extra-firm	
Firm	**Type 1**	**Type 2**	**Type 3**	**Type 4**
ArvinMeritor		X		X
Bosch		X		X
General Motors		X		(X)
Mahle	X	X	X	
VW		X		(X)
ZF Sachs	X	X	X	

Source: Author's own fieldwork: Quadros (2009). Note: The lead firms sample includes both assemblers and multinational OEM suppliers. (X) denotes indirect ODIP, from subsidiary to supplier.

technological research and experimentation. Such units are in charge of exploring the development of new technologies to be incorporated into the products not just in Brazil but worldwide. These R&D units were not built from scratch but based on previous R&D capabilities developed within the Brazilian firm (Mahle Metal Leve) or MNC subsidiary (BorgWarner).

The German corporation Mahle took over the well-known Brazilian auto-parts firms Metal Leve and Cofap in 1996, and benefited from both companies' two decades of building R&D capabilities. The knowledge and capabilities acquired from Cofap and Metal Leve have been the platform on which Mahle has built its Brazilian Technological Centre, which is one of the five centres of Mahle's global R&D network. The Brazilian subsidiary can be expected to play an increasingly important role in research. It is leading a research consortium which seeks to produce new scientific knowledge on the peculiar tribological challenges of flex-fuel engines. The consortium includes multinational auto assemblers (VW, GM, Renault and Fiat), Brazilian energy firms (notably Petrobras) and academic research groups from the Universities of São Paulo and Campinas.

The R&D carried out by ZF Sachs is concentrated in its Friction Materials Business Unit (FMBU) and Laboratory – FM Lab. The German Headquarters decided to concentrate R&D facilities in Brazil because the subsidiary had more experience and competencies at the time of the decision. Decades of previous accumulation of local technological capabilities has contributed to the global status of this R&D unit, as ZF Sachs benefited from the experience of the BorgWarner subsidiary in Brazil, whose acquisition was the gateway for Sachs into the Brazilian market.

6.2.2 Type 2 – Delegating the development of new products to Brazilian subsidiaries

The main pattern of ODIPing in the Brazilian automobile value chain is one of decentralising NPD. This is prevalent because MNCs are the primary drivers of ODIP in this industry and, so far, ODIP type 2 prevails over ODIP type 1 amongst global assemblers and auto-parts suppliers. This tendency is reinforced by the vast predominance of NPD in innovation activities and investment in the auto industry, as seen above.

General Motors is a good example. In 2005, GM headquarters granted the Brazilian products development engineering unit the status of competence centre for product development,[17] thus becoming part of the network of five product development centres. This was followed by an incremental increase in product development staff, from 400 engineers in 1999, to 660 engineers in 2005 (Quadros and Queiroz 2001; Balcet and Consoni 2007). In 2007, the plant employed 1,300 engineers in product development.[18] The status of centre of competence for product development engineering followed the completion of the Meriva project. The Chevrolet Meriva was developed for the global market by GM do Brasil's Technological Centre in São Caetano do Sul, in the Metropolitan Area of São Paulo. Today the Brazilian product development unit is in charge of product development of global middle-sized SUV architectures, as well as designing regional derivatives for the Latin American area. For some models, for example GM's Hummer brand, the product development takes place in Brazil, but the manufacturing is carried out elsewhere.[19]

Volkswagen do Brasil's (VW) product development engineering unit has also gained importance as a platform for product development. The development of the Fox model was the milestone that signified the mastering of all phases of product development. According to the CEO of the Brazilian subsidiary, the Brazilian product development unit specialises in entry-level cars and may be assigned product development tasks aimed at other markets. Although in the late 1990s VW had considered a more centralising approach to product development management, which would have meant strengthening Germany at the expense of Brazil, this is not what happened eventually. VW expanded its product development staff, from 450 engineers, in 1999, to 650 engineers, in 2005. This does not take into account the 400 product development engineering staff of VW T&B, which is a separate company and will be dealt with in chapter 7. Recent product development infrastructure investment by VW in Brazil comprised a US$ 2.5 million virtual reality, 3D project room, which was inaugurated by German Chancellor Angela Merkel in May 2009. In the next five years, ten new VW car models are scheduled to be designed in the São Bernardo product development unit, as compared to 15 models that were developed throughout the entire history of the subsidiary.

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17 In 2006, the product development engineering unit located in GM do Brasil's Technology Centre has become integrated into the newly created Global Architecture Development Team (GADT). GADT has been organised by GM Corporation as one, integrated and global NPD engineering operation, based on a network of five centres located in the US, Germany, Korea, Brazil and Australia.

18 Information collected in interviews. Rick Wagoner GM global CEO reported to the press that 2,000 employees were involved in product development, at the close of 2007. His expectation was that this staffing level would grow to 2,800 employees by the end of 2008.

19 GM's product development test ground in Indaiatuba, state of São Paulo, is the third in terms of importance and value of investment amongst GM's test grounds in the world. Recent product development infra-structure investment by GM in Brazil comprised the implementation, in 2006, of a virtual reality, 3D project room, a facility that only Embraer, the aircraft manufacturer, had in Brazil until then (Quadros 2009). The project of the architecture of the Meriva, which was launched as a global model, was entirely carried out by GM's product development unit, at São Caetano technology centre and Indaiatuba test ground and labs. The Meriva project led GM's Brazilian subsidiary to substantially upgrade its product development capability, because through this project the product development staff mastered all phases of product development, from concept to validation (Consoni and Quadros 2006).

ArvinMeritor and Bosch are examples of multinational OEM suppliers adopting cross-border ODIP type 2 towards their Brazilian subsidiaries. These now have mandates for NPD and became centres of excellence in particular product lines, but since the 1980s they have systemically pursued capabilities in NPD and increased their product engineering areas. They have started by searching for incremental product changes, mostly designed to meet local market needs: adapting components to requirements of local fuels, materials and road conditions. Today, as centres of excellence, they have developed product innovations (‘our innovation events, Table 5.7) which have been based on internal R&D and protected by patents.

Bosch is the largest supplier of systems and components to the automotive industry in Brazil. The focal point of this research was the Gas Systems (GS) division of the Brazilian subsidiary. The Brazilian GS division is the corporation’s centre of competence for biofuels. This is so not only because biofuels related components are strategic for Bosch worldwide, but also because the subsidiary has invested in researching, developing and testing ethanol fuel systems for more than 20 years. Bosch’s flex-fuelling systems, even though originally aimed at Brazilian flex-fuelled passenger cars, have placed the Brazilian Bosch engineering team in a strategic position within the corporation. Their experience with flex-fuelling systems, which work with petroleum gas, ethanol or natural gas, has opened up the Brazilian engineering unit to unprecedented possibilities of cooperation with other subsidiaries and headquarters, as biofuels become increasingly important worldwide. The development of competencies in flex-fuel systems has been responsible for the considerable increase in Bosch do Brasil’s R&D efforts. The group of five professionals who started the ethanol fuel systems in the 1980s now has more than 120 engineers and technicians working in flex-fuel systems (almost half of the R&D engineering staff). Bosch’s interviewees reckoned that the R&D/sales ratio in the Brazilian subsidiary was approximately 2 per cent (which is equivalent to € 80 million).The most recent flex-fuel incremental innovation of the Brazilian subsidiary – the smart start flex system, which eliminates the need for gas injection when the engine is started – was granted the 2010 Global Bosch Innovation Award.

The case of ArvinMeritor is smaller in scale, but significant for understanding ODIP knock-on effects (chapter 7). ArvinMeritor R&D is organised as a network of four units, comprising three engineering centres and the India Tech Centre, which specialises in software services. The Brazilian product engineering unit employs 24 engineers dedicated to NPD, including a few engineers holding masters degrees and one PhD. The Brazilian engineering group works in an integrated manner with the North American and Italian units. The Brazilian team is responsible for two types of job: either participating in global projects by developing specific tasks and jobs, or carrying out the development or adaptation of products for Latin American customers. Even though this is a relatively small team, and the expenditure of ArvinMeritor in R&D in Brazil represents only 1 per cent of revenues, the engineering team alone was responsible for submitting 18 patents in the period 1999–2005. Some of the innovations extended to global products were originally developed by this team, as illustrated by the innovation events listed in Table 5.7.

Table 6.2 Internal and external ODIP of automotive lead firms in Brazil

Internal ODIP*	External ODIP**
General Motors	VW Trucks
Volkswagen	GMB
Fiat	ArvinMeritor
Ford	Bosch
Renault	Ford
PSA	Renault
Daimler (trucks)	PSA
Bosch	Daimler (trucks)
ArvinMeritor	Delphi
Mahle	Visteon
ZF Sachs	Dana
Delphi	Magneti Marelli
Visteon	Valeo
Dana	VDO
Magneti Marelli	TRW
Valeo	
VDO	
TRW	
Pirelli	

Source: Interviews, press reports and secondary literature.
* Company-internal decomposition of the innovation process from headquarters in Europe or the USA to Brazil.
** Decomposition of the innovation process from the lead firm in Europe or the USA or from its subsidiary in Brazil to the Brazilian owned suppliers.
Note: This is a list of examples not restricted to sample firms; it does not claim to be comprehensive.

6.2.3 Summary

This section has focused on ODIP types 1 and 2 carried out by auto lead firms operating in Brazil. The first column in Table 6.2 indicates that such company-internal but inter-continental ODIP is very common, not limited to the sampled firms.[20] The second column indicates there is substantial outsourcing of innovation from the (multinational) lead firms to Brazilian-owned suppliers. These ODIP types 3 and 4 are typically practiced by the Brazilian subsidiaries rather than from headquarters in the US or Europe. ODIP types 3 and 4 are often a derivative of types 1 and 2 and require separate analysis which will be presented in chapter 7.

6.3 Software industry: ODIP and new spaces in India

In the Indian software industry, we observe the same types of cross-border ODIP as in the Brazilian auto industry – see Table 6.3. However, Type 4 plays a bigger overall role because of the larger volume of software activity undertaken by independent suppliers (as opposed to software subsidiaries).

20 Following the steps of the market leaders, Renault has increased substantially its product development unit in São José dos Pinhais, state of Paraná and established its South American Design centre in the city of São Paulo. PSA is also building a substantial product development unit located in São Paulo (Quadros and Consoni 2009).

Table 6.3 Types of ODIP – software lead firms

	Internal		External	
Firm	**Type 1**	**Type 2**	**Type 3**	**Type 4**
Bosch	X	X		
HP/EDS		X		
Nokia				X
Passalong				X
SAP	X	X		
Siemens (SISL and SCS)	X	X		
Symbian		X	X	X
Volvo IT				X

Source: Firm interviews.

6.3.1 ODIP Type 1 – Decentralising the R&D department with substantial units in India

This is the least prevalent type of ODIP in the case study firms, but it is increasing. SAP has a two-tiered R&D structure. First, SAP Research is based in Waldorf, Germany and has a number of business units in lead markets around the world. These units are authorised to identify and shape new IT trends and to explore opportunities that have not yet been developed into products. Second, there are eight SAP Labs that design and develop new software solutions that enhance and extend SAP Business Suite and work on new functions and releases. The Bangalore site performs both of these functions. The subsidiary employs around 10,000 people of whom about 25 per cent is committed to research and next generation product development in the SAP Research network.[21] Bosch also has a major R&D operation in India (mainly Bangalore). Robert Bosch Engineering and Business Solutions (RBEI) is the software division of Bosch in India, with over 5,800 associates and the largest development centre of Bosch outside Germany. As RBEI states on its website: ‘The remarkable thing about the systems that document the innovative strength of our company is that much of their intelligence now comes from India’.[22] This is backed up by the fact that RBEI in Bangalore had filed for more than 50 patents at the time of fieldwork.

6.3.2 ODIP Type 2 – Delegating the development of new products to Indian subsidiaries

This type of ODIP was more widespread in the sample and sometimes a companion of the internal decentralisation of R&D. In 2000, SAP Labs Bangalore started with localisation of existing products but today the independent new product development efforts of SAP Labs Bangalore has a global reach. Today, in the words of the CEO Claus Neuman, Bangalore is ‘no longer just given work that is pre-defined and thought through somewhere else’. However, there is still a division of labour. Neuman explains the division between Waldorf, Germany and Bangalore:

21 Source: www.sap.com/india/about/company/saplabs/index.epx (accessed 1 August 2009).

22 Source: www.boschindia.com/content/language1/html/14089.htm (accessed 1 August 2009).

> *We do the platforms elements that need integrated engineering in Waldorf. And we do a lot of innovations that sit on the platform in India. You can compare this with a car. A car manufacturer makes a platform that needs in the end to fit many products. And this platform is engineered in Germany, but all the things that make the difference for the customer – the user interface, the analytics, the reporting and all the things that are the touch and feel of the product – they come from India. On those design-oriented features, we have realised that the Indian colleagues are more innovative.*

One example is the SAP Business ByDesign product (released September 2007), a flagship product in SAP's efforts to extend its reach into the mid-market for ERP (enterprise resource planning) applications. While the suite has been launched globally including in the US and Germany markets, SAP Labs Bangalore could draw on the experience and knowledge derived from the Indian market as this product addresses a distinct market of medium-sized business (100–500 employees), including firms that have not before invested in advanced ERP solutions.

> *We said OK here's a product. You get the responsibility; now you have to fulfil the KPIs [Key Performance Indicators]… And it worked. The whole customer interaction, the user interfaces and the whole way this software works is all coming from Bangalore. And they did this with a completely new approach to software development that means there is no hands-on coding anymore – it is a model-based development process, so people put models together instead and you have to think this through very carefully. It means that the development processes as well as the product are both complete innovations – and both coming from Bangalore… The customer satisfaction went up and the speed of innovation went up.*
> (Interview with CEO Neuman of SAP)

Some of the pressure for moving in this direction came from the employees. Job satisfaction was not very high in the Indian subsidiary because the 'old' way of working – in which Indians worked to tight specifications under German leadership – was found to be unchallenging by many. In order to attract and retain experienced staff SAP leadership realised that changes were needed. In a step away from this model, Bangalore was mandated with the 'ownership' of complete separable business domains. For instance, Bangalore was given responsibility for the SAP Apparel and Footwear Solution and the SAP Oil and Gas Solutions. They are now completely run out of India. Furthermore, the modes of interaction have changed in distributed development projects, i.e. projects that are co-developed by different organisational units (in this case different subsidiaries within SAP). SAP moved to deeply integrated virtual teams in which all staff in the team interact with each other. Developers in Germany interact with developers in India, managers in Germany with managers in India and they have to align with stakeholders across SAP's many units across the globe. This rise in subsidiary status was accomplished in the mid-2000s. Before that the Indian teams were always clearly guided by experienced colleagues from Germany. SAP would always send a colleague to India or they would receive very detailed specifications to work on.

There is some evidence of corporate heterogeneity, implying that large firms operate with multiple models that have different (offshore) innovation policies. An illustrative example is Siemens, which has multiple engagements in India. The two units interviewed for this research were Siemens Communication Systems (SCS) and Siemens Information Systems Limited (SISL). SCS, a business unit focused on the manufacturing of telecom equipment, has an 'advanced' policy with a wide mandate for its Bangalore subsidiary. The subsidiary performs the full range of activities from design to testing. Siemens Information Systems Limited (SISL), on the other hand, has delegated only traditional programming tasks to its Bangalore subsidiary. This means that the tasks in software development accomplished offshore are limited to 'execution' in the sense of fulfilling highly specific and predefined tasks. The German business unit constructs very detailed specifications for products and systems and the Indian business unit (SISL) is focused strictly on execution. IPRs, if developed in the course of software development, remain in the hands of the customer (Siemens AG in Germany). In other words, SISL is not part of the *innovation* network in Siemens. The reason for this difference is found in the competence profile of the 'sponsor organisations' of the two Bangalore subsidiaries. In SCS, the core business is not software development and they depend on their Indian unit for the software inputs into manufactured equipment. In the case of SISL, the sponsor unit is itself a software developer, working to the requirements of external costumers. They offshore only labour intensive parts of the software development process. Even though SISL is co-located in the same building with a Siemens Corporate Technology Unit (part of the Siemens global R&D network) in Bangalore, linkages between these two Siemens subsidiaries are virtually non-existent.

A more cautious 'India Mandate' is also observed in Symbian. While based in the UK, the firm is heavily globalised relying on a network of internal and external providers for certain aspects of technology development. The division between internal and external is guided by a set of five policy categories for labelling the code. The label denotes the legal arrangements that should underpin development activities. The highest level is a confidential source code, which it does not distribute at all: all development activities remain in-house in the UK. Another category is a jointly developed source code, which can involve external providers by special legal arrangement. In 2003, Symbian started an outsourcing relationship with Kshema Technologies, a Bangalore-based software services firm. Kshema established an overseas development centre for Symbian and driven by cost advantages, became a major partner for the development (implementation) and maintenance of certain parts of the code in non-critical categories. Operating at this level Kshema was not initially involved in independent design activities for Symbian. However, to make more use of the qualified Indian resources for more central parts of the system, Symbian made an agreement with Kshema that it would acquire the offshore development centre that had been established in the Indian firm. This centre was then made a captive Symbian unit. In this way, some source code design activities that are closer to the core of the system (high-level design) have become relocated to the captive unit in India.[23]

Kshema was also involved in pushing innovation activities into the Indian portfolio of activities of HP/EDS. EDS had acquired MphasiS that – in turn had bought – Kshema Technologies. Through this route, HP came to own a customer relationship in which the Indian operations were responsible for maintaining a

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23 Kshema was then absorbed by MphasiS – and later EDS/HP.

billing and operations support solution for a US Internet infrastructure solutions provider. This solution, previously developed by Kshema/MphasiS, shows how ODIP is not always a conscious decision, but something which lead firms get involved in ‘through the back door’.

6.3.3 ODIP Type 3 – Cooperating in technology development clubs

Commissioning standalone research directly from independent organisations in India is not commonplace, but there is increasing engagement of independent Indian firms in technology development clubs. For instance, the WiMedia alliance is an open association that promotes the adoption, regulation, standardisation and multi-vendor interoperability of ultra wideband (UWB) worldwide. It was through the participation in this network that one lead firm (not in our sample) interacted with Wipro which eventually developed its UWB solution.

Some clubs are more closed in nature. Symbian built a Network of Symbian Competence Centres (SCCs) to create an ecosystem of Symbian developers outside their own organisation, but within their controllable reach. To do this, Symbian designates SCC status to external organisations of their own choice. In this capacity, Sasken now provides services to licensees of the Symbian operating system (OS). It maintains a focus on software development and integration skills to work with a wide range of technologies for use with the OS. Sasken established a new organisational entity for distinct technological domain offerings, providing licensees of Symbian technologies with component design, software development and testing. In developing the Symbian Competence Centre, for instance, Symbian played a key role in training and auditing Sasken capabilities and processes. This enables them to function as a certified competence centre working with third-party users of Symbian technology. It is an example of how some global lead firms actively share knowledge and invest in Indian firm capabilities as the business and innovation process becomes more decomposed.

6.3.4 ODIP Type 4 – Engaging Indian suppliers of products and services in innovation

In volume terms, the sourcing of software from multinational subsidiaries is not as important as sourcing from Indian suppliers (through cross-border trade). There is limited recent comparative data, but in the late 1990s, MNC subsidiaries accounted for 16 per cent of software exports (Giarratana *et al.* 2005). In other words, the *outsourcing mandates* of independent buyers are probably more important than subsidiary mandates in MNCs. Major new opportunity spaces for supplier innovation are created by the demand of buyers. These spaces differ across buyer segments. Within product development software services, buyers such as Nokia have defined clear product development strategies with clearly defined needs for software components. They outsource such elements to India because suppliers there have developed semi-generic competences and solutions such as components to enable Bluetooth connectivity in mobile phones. Buying these from India along with the required customisation services provides a cost-advantage to their product development efforts. By contrast, the spaces within the business process software service segment are typically not clearly defined. The contours are fluid, becoming clearer only in the course of the interaction with the

Table 6.4 Internal and external ODIP of software lead firms in India

Internal ODIP		External ODIP
Adobe	Hewlett-Packard	Alcatel
American Express	IBM Global Services	Cisco
Baan	Intel Novell	Computer Associates
Cadence Design Systems	Microsoft	Ericsson
Cisco	Motorola	Farmer's Insurance
Citigroup	Oracle	General Electric
Computer Associates	Philips	General Motors
Cognizant	SAP	Home Depot
Deutsche Leasing	Siemens	IBM
EDS	Sun Microsystems	Lucent
Ericsson	Synopsys	Motorola
General Electric	Texas Instruments	Nokia
General Motors	Yahoo!	Nortel Networks
Google		Xerox

Source: Adapted from Mitra (2007).

supplier. The client is looking for a solution but does not know exactly where it lies and what it entails. For example, a business unit such as Volvo IT may draw on its Indian partner to come up with a new CRM system for an internal customer in the Volvo group. The internal customer has defined the problem but the solution is not clear. The Indian partner (MindTree) has the ability to add value to the innovation because it has general expertise in CRM systems and has worked with a range of automotive firms. While Volvo IT has the detailed contextual knowledge, the Indian partner contributes centrally to the innovation process (development of the new CRM system) by drawing on its accumulated knowledge base. Thus, these types of buyer firms are expecting more value from their software process suppliers than just the traditional cost advantages derived by outsourcing IT services. Furthermore, the 'comfort levels' rise over time. In the cases reviewed, the propensity to outsource innovation tasks depends on the competence demonstrated by suppliers in previous projects. The effect of such changing sourcing practices is discussed in the next section.

This section has examined ODIP based on information from our sample firms. Table 6.4 shows that they were not exceptions. This table lists many other multinational subsidiaries with major company internal R&D operations in India or R&D activities outsourced by these subsidiaries to Indian firms.

6.4 Limits to innovation: spaces and their boundaries

While there is evidence of remarkable accumulation of innovation capabilities over the last 10–20 years and indications that ODIP has had an important influence in this regard, it does not mean that there are no upper limits to this process. These boundaries are constantly evolving but at any given point in time, their limits have an influence on the space in which suppliers can innovate. We draw on the modularity and systems integration literature (Brusoni 2005) because its distinction between problem framing and problem solving helps to bring out the limits. However the power of this distinction is greater in the software industry than in the auto industry, reflecting differences in the technology and configuration of global value chains. And the picture is by no means uniform within these industries.

6.4.1 Brazil

As shown in section 5.2, some Brazilian suppliers in the automobile industry now have all the technical knowledge for innovating a particular part or subsystem. However, the assemblers have, and indeed require, the capability to integrate this particular subsystem into their overall system and strategy. In this sense, there is a division between problem-framing activities in assembler firms and problem solving in supplier firms. Nevertheless, this division is not as neatly drawn as it might seem at first. Some suppliers – for instance, Bosch and other systems suppliers – are themselves powerful lead firms and have a big influence on the systems and strategies of the assemblers. They supply black-box solutions, which are protected by patents and are beyond the knowledge and control of assemblers. To be sure, even these big global suppliers develop solutions to the general performance and interface requirements set by assemblers (Humphrey 2003: 22). New trends in supplier network strategy and management infuse an element of open system development into the architectural design of cars and even more so in trucks (Moavenzadeh 2008), but this influence on the macro design of vehicles rarely extends to locally owned suppliers. This is closely related to the R&D profile of lead firms and Brazilian suppliers.

In the automotive industry, R&D is distributed between two distinctive, though complementary areas: a technology research and development area and a product development area. Research by Strambach (2009) and Quadros and Consoni (2009) shows that lead firms in the auto industry undertake product and process development (in product development engineering units and/or corporate product engineering networks). This is distinct from the work in corporate research units that undertake research activities and technology exploration that feeds into major new features and functionalities in new product platforms or generations. These can be considered strategic innovation activities, meaning that, as long as the future of the automobile industry is influenced by assemblers' technology strategy, these activities are the most connected to the definition of the future of the business. Our research suggests that lead firms continue to keep these strategic innovation activities for their R&D units located in Europe and the USA.[24]

In Brazilian supplier firms, there is typically no unit with a specific mandate for applied technological research, except for Mahle Metal Leve and ZF Sachs. R&D staff work alongside engineers in efforts to solve concrete problems. This means that product development engineering is not organisationally separated from technological research. The Brazilian part of the global value chain is primarily dedicated to product and process design, not only for local or regional markets, but increasingly also for global markets. When problems arise in the course of ongoing new product development, such problems are tackled by Brazilian OEMs or suppliers (either MNCs or national suppliers) which eventually develop new technological solutions and generate patents. Even though national supplier firms in this research have carried out problem identification and research to solve these problems– as seen in the cases of Sabó, Lupatech, and Arteb –

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24 As shown by Clark and Wheelwright (1992); and Wheelwright and Clark (1992), *technology* planning and strategy and *product development* planning and strategy are two clearly distinct, though integrated dimensions in the innovation process, responding to different time constraints and challenges.

technological research is rarely strategic for the car or the value chain. Our research suggests that the relocation of product development activities to Brazil creates opportunities for local suppliers to engage in co-development, but it also limits the scope of such innovation activities. In a dynamic perspective, one would expect this scope to increase over time.

6.4.2 India

In the software industry, buyer segments differ with regard to the space given to independent suppliers. Electronics and telecoms firms (such as Nokia) mainly outsource problem solving and innovation support activities. Suppliers feed into highly coordinated networks and innovation processes in which Indian service providers play a specialised and bounded role. Physical product design and related activities are typically kept in-house (or outsourced to specialised providers of hardware design services). The interface between the software component and the overall product is specified by the overall product design (and the technical standards). This has implications for the division of labour between buyer and supplier. The buyer oversees the design of the overall product (e.g. a chip or wireless device) and defines the functional requirements of the component. These specify the behaviour of the component and the interface (external design). The supplier is left with responsibility for non-functional requirements (such as performance, security and reliability) and internal design. The buyers provide carefully defined and limited spaces in which suppliers can innovate.

In contrast, where the buyers are software companies or software departments (primary and secondary software buyers), they often adopt a different practice. As mentioned, suppliers are often invited to participate in requirement-definition activities in a substantial way. It is this limit to codifiability, and the resulting needs for buyer–supplier interaction that explains why co-framing of requirements was widespread. This is discussed further in chapter 7 which examines in more detail ODIP Type 4 relationships. Buyer firms expanded the outsourced value-chain thread from implementation activities all the way into the realm of problem framing. It is not easy to stop and draw a clear line of demarcation at the stage of problem solving.

This does not mean that the distinction between strategic and non-strategic has vanished. In some cases, the strategic innovation processes are becoming non-technical. Instead of focusing on product and systems development, managers focus on developing new business models in which the critical component is the customer interface. Internal resources are deployed in the areas that enhance user knowledge and sales capability, in managing other external relationships and in capturing rent from new business models. The issue of strategic innovation arises mainly in firms that are willing to let go of component knowledge (problem solving), while they seek to retain architectural knowledge (problem framing). In this scenario, architectural knowledge is what matters and knowledge spillover arising from buyer–supplier interactions is a dangerous threat. However, when the rent-generating processes move forwards towards the user, the strategic importance of architectural knowledge is reduced. This insight applies to the software industries, but not to electronics. It shows, however, that the ‘modular view’ and the associated view of labour division have limited applicability for a new generation of firms for which competitive advantage and profitability increasingly lie outside technical areas and within areas of relationship management and the ability to understand customer problems. Related research on the German software industry generated findings which support the findings presented here: ‘Software firms in Germany refocus on higher-value tasks which often depend very heavily on vertical knowledge and – quite often – on experience-based knowledge of the customers’ business processes generated over long-term relationships’ (Oswald 2008 :72). Buyers tend to keep high-level design activities at home, but some vanguard firms are now beginning to outsource these to offshore locations.

As these dynamics evolve, new upper boundaries emerge. Technical problem framing, and sometimes even certain aspects of non-technical problem framing, have become less strategic for certain buyers. The new strategic core lies increasingly in non-technical areas and the customer-facing units. This was clearly expressed by buyers. As an informant stated: ‘We do not want to bring in someone else to take the layer between us and the customer’ (Volvo IT). Controlling access to the customer is increasingly vital both for standalone software houses and for internal IT units of manufacturing firms (such as Volvo IT) since the latter increasingly compete and survive on market-based conditions. For buyer firms in the software industries, cognitive and cultural proximity to their own client or customer base is therefore a strategic capability. Suppliers are confronted with a boundary which is essential for furthering business relationships. In the words of the Infosys manager: ‘This is where the boundary is and that has to be respected.’ In other words, the upper limits of the current innovation space are clearly defined.[25]

6.5 Conclusion

In addressing the extension of ODIP to Brazil and India, this chapter has examined the types of cross-border ODIP practiced by lead firms in the chosen industries and the initial implications for their local suppliers. The lead firms have delegated major innovation functions to their subsidiaries and to independent suppliers in Brazil and India. These functions tend to be highly specialised and concentrate on product development. The organisational and locational decomposition of innovation means that lead firms provide new ‘mandates’ and ‘spaces’ to subsidiaries and suppliers in Brazil and India.

The cross-border reconfiguration of formally organised technology research and exploration activities was weak in both sectors. Our results confirm the observations that multinationals tend to keep the formal research stage of the innovation process in the home economy. However, a few firms seem to be gearing up their research activities in newly formed R&D departments in Brazil and India. None of the lead firm headquarters (in our sample) commissioned research directly from external organisations in these countries. The still limited relocation of formalised and specialised research activities confirms the continued strategic importance of these activities to lead firm HQs. Substantial innovation spaces have arisen in both India and Brazil, but these are bounded by the strategic concerns of innovation organisers residing within Europe and the USA.

25 Nandan Nilekani, then CEO at Infosys: ‘You have to be close to your customers. That is what companies need to do. They do not want to outsource that, and they shouldn’t. But everything else can be outsourced’ (quoted in Nussbaum 2006).

The cross-border decomposition of product and process development, improvement and problem solving is much stronger in both sectors. This suggests that lead firms tend to disperse *non-research based* product and service development activities to either subsidiaries or suppliers. This does not mean that research played no role but the emphasis was on development (it tended to be r&D). The next chapter shows that the cross-border ODIP to Brazil and India leads to further intra-country ODIP and how this succession of organisational changes contributes to the build-up of innovation capabilities. ODIP creates new spaces and the question is whether and how these new spaces are occupied. What emerges from the next chapter is that local suppliers are taking advantage of these opportunities and deepening their innovation capabilities.

7 Implications for local suppliers in Brazil and India

The previous chapter showed the patterns of ODIP practiced by lead firms *across borders*. This chapter analyses what this means for *local firms* in Brazil and India. While the previous chapter took the view from above, examining ODIP patterns and processes through the lens of the orchestrating firms, this chapter takes the view from below, analysing how local suppliers are affected. What are the implications for the relationships with their customers, for their role in the value chain, and for their participation in the innovation process?

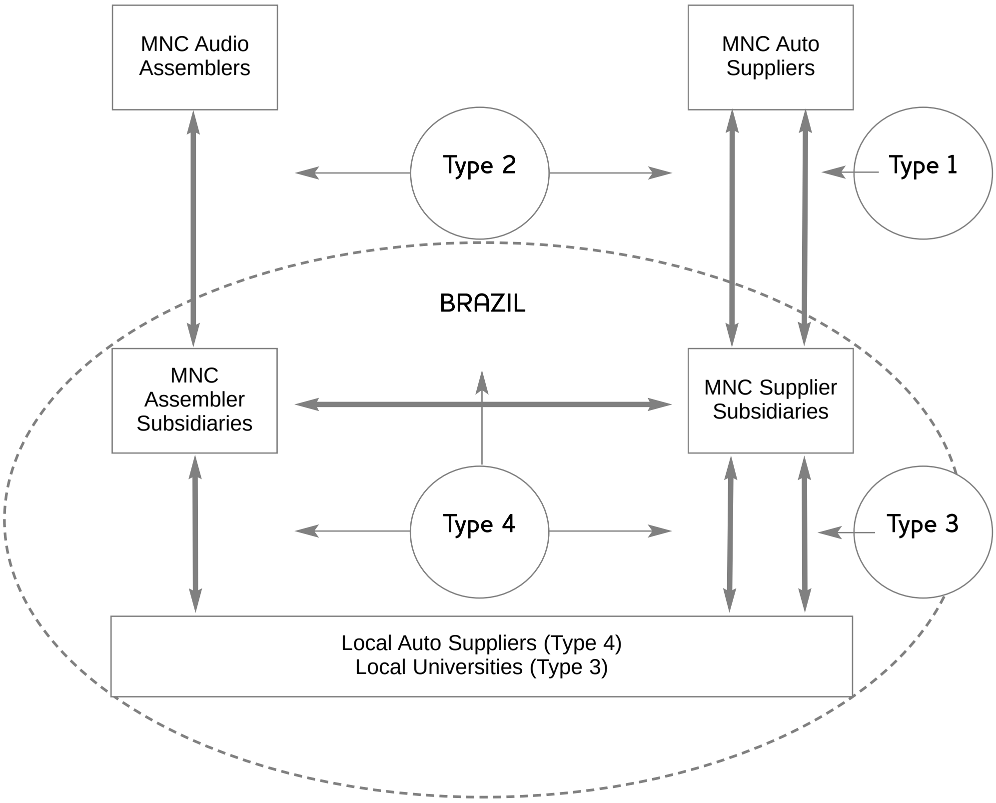
Section 7.1 maps the ODIP relationships under study and examines knock-on effects by concentrating on the (potential) knowledge-linkages between firms within Brazil and India. It shows that ODIP has taken different paths in the two cases. However, Section 7.2 shows that there are important features that are shared between the two cases: the advancement in capability has been closely related to the attainment of co-design contracts by supplier firms. By engaging in this type of contract, the linkages to buyers have undergone substantial changes with the increasing importance of uncodified information and tacit knowledge. While following different routes, ODIP has created important learning spaces in both cases. An important element is the nature of the knowledge centred interaction associated with the ODIP occurring in the immediate parent firm or customer. ODIP changes the relationships between firms in the value chain and this has the indirect effect of contributing to the effectiveness of the interaction as a route to deepening capability.

7.1 Different ODIP paths

7.1.1 ODIP in the Brazilian automotive industry

In the auto industry, we can observe a sequential pattern; first there was intra-firm cross-border ODIP which was followed by inter-firm intra-country ODIP or – to use a different language – the outsourcing of innovation to local suppliers. This is why Quadros (2009) argues that the more MNCs delegate innovation activities to Brazilian affiliates, the greater is the propensity that it will draw local suppliers into the innovation process. The increased innovation responsibility of the affiliate creates demand for co-development and services. For example, co-development in

Figure 7.1 Cross-border and in-country ODIP in the Brazilian auto industry



cases like Arteb, Letande, Masters and Sabó means that the supplier develops the design of the component and even provides technical solutions for problems that need to be addressed – following the dimension and performance requirements defined by the assembler.

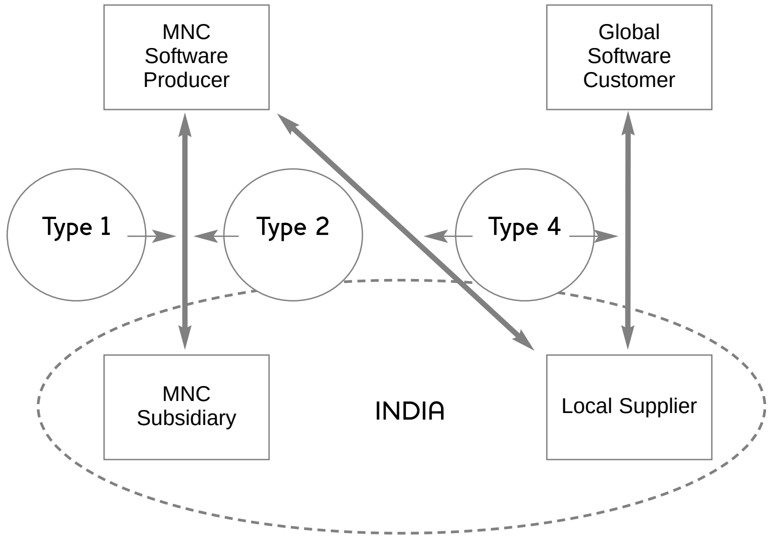
These processes are depicted in Figure 7.1. As MNC subsidiaries in Brazil – both assemblers and suppliers – gain global mandates for product/process development, they pass on some of the design and engineering activities to suppliers and service providers. The *cross-border* decomposition of innovation activities *within firms* (ODIP Type 1 and particularly ODIP Type 2, involving MNC headquarters and subsidiaries) is closely associated with – and indeed a driver of – the *localised* decomposition *between firms* (ODIP Type 4).and between firms and local universities (ODIP Type 3).[26]

7.1.2 ODIP and the Indian software industry

The Indian case is markedly different – see Figure 7.2. In the software industry, the opportunities for supplier innovation typically emanate directly from multinational and global buyers located in the US or Europe. In this case, ODIP involves the offshore outsourcing of innovative activities to suppliers in India. It is a case of *cross-border* decomposition of innovation activities *between firms* (ODIP Type 4, involving MNC headquarters/buyers and Indian owned suppliers). As

26 In the cases of Sabó and Lupatech, local suppliers have started supplying new designs directly to the MNCs in the US and Europe, but this is not yet common.

Figure 7.2 ODIP and the Indian software industry



discussed, there is also *cross-border* decomposition of innovation activities *within firms* (ODIP Type 1 and particularly ODIP Type 2), but this creates very little demand further in the value chain. In fact, none of the innovation events studied involved linkages between MNC subsidiaries and Indian software suppliers.

When linkages between MNC subsidiaries and local software firms occur these are rarely innovation-centred. They are typically arrangements in which (i) local suppliers receive contracts related to the installation/implementation of MNC software products in government and private sector firms in the Indian market or (ii) local suppliers lease out programming staff to MNCs for short periods to relieve bottlenecks (a localised body-shopping practice known as staff supplementation).

This does not mean that ODIP does not give rise to its own dynamics within India. On the contrary it creates and supports an important own dynamic, but the effect is direct and occurs *within* firms rather than between firms. As shown by Lema (2010), innovation outsourcing of software services in different knowledge domains creates effective learning dynamics within firms in the supply base as they combine knowledge and learning in different knowledge domains. The bringing together of these knowledge streams enables the creation of 'new combinations' which amounts to the deepening and application of capabilities (competence leveraging). To a certain degree, these dynamics are akin to intra-firm ODIP because the suppliers strengthen associated centres of excellence (CoE). However, these CoEs and R&D departments are rarely dispersed and this is why we do not stretch the ODIP concept to view these instances as extra-firm ODIP leading indirectly to intra-firm ODIP.

7.1.3 Reasons for the differences between the two sectors

There are two interrelated reasons for these different ODIP paths. First, the local market has played an important role in the Brazilian automotive industry. MNCs located assembly plants in Brazil from the outset and later transferred some innovation activities to these subsidiaries. By contrast, the local Indian market has played an insignificant role in offshoring and outsourcing. Lead firms (multinationals and global buyers) in the OECD countries worked directly with Indian suppliers and then incorporated the software codes in products and systems for OECD markets. The second reason is technological in nature and has to do with sectoral product specificities. In the automotive industry, design and production is separable as the use of computer-aided technologies has increased the efficiency and precision of product specifications. This means that automobiles can be split up into a multitude of parts, often with their own distinct and specialised knowledge base (mechanics, engines, clutches, lighting, etc.) and the lead firm increasingly concentrates on the integration of composite knowledge (Strambach 2009). In the software industry modularisation is impeded because of the limits of the division of labour in software design (Piore 2004). Each software system is unique and this has limited the possibility of making interchangeable (independent) parts and standardised interfaces; rather software systems tend to consist of *dependent* modules and integration is therefore difficult. This difficulty and the associated cost of coordination increases with the number of organisations involved and lead firms tend to prefer to work with a single supplier for each project (even though multi-vendor arrangements for large projects has increased in recent years). These features of design are discussed further below.

7.2 Buyer–supplier relations in co-design and solution development

7.2.1 Co-design in the Brazilian automotive industry

As mentioned above, auto assembler subsidiaries were expected to reproduce the supplier choices made by the parent company but this only happened to some extent. Brazilian subsidiaries (both assemblers and component makers) have considerable autonomy for choosing suppliers according to competences, quality, costs, and so on. This applies in particular when the Brazilian subsidiary is leading the product development project. It induces the subsidiary to look for co-development partners amongst Brazilian suppliers, either global brands with operations in Brazil or national Brazilian suppliers.

Brazilian national suppliers are not exclusively second tiered in the innovation chain. Indeed, as they upgrade their innovation capabilities, OEM national suppliers like Arteb, Lupatech and Sabó are directly involved in co-design with assemblers' subsidiaries. Some of the Brazilian national suppliers have taken a further step up the ladder and are getting involved in innovation projects led by assemblers' headquarters or their European subsidiaries. Arteb and Lupatech provide innovation inputs directly from Brazil to General Motors. Sabó has worked with Volkswagen in Wolfsburg and done so via Sabó's European subsidiary.

Even when follow sourcing is used in Brazil, there may be downstream co-design involved in the projects. The collaboration between Volkswagen Trucks and Buses (assembler) and ArvinMeritor (multinational OEM supplier) exemplifies how this unfolds. When ArvinMeritor became suspension and axle module supplier to Volkswagen Trucks and Buses in Brazil, it also assumed the role of centre of competence for the development of this module. Yet, as ArvinMeritor's Brazilian subsidiary was strong in axles and not suspensions, it mobilised Brazilian national suppliers Suspensys, SIFCO and Freios Master to co-develop and supply suspensions, non-tractive axles and brakes to complete the module.

All eight national suppliers in the sample have been heavily engaged in co-design with their customers. In the words of SIFCO's product development manager:

> *The automotive supply business has changed from supplying components to supplying component design and manufacturing services and those who have not understood this risk being displaced from the business.*

In the past ten years, the automotive value chain in Brazil has gained in complexity and diversity of activities, becoming also an innovation chain in which Brazilian suppliers are included.[27] This tendency to provide customised solutions that integrate products with knowledge-intensive services (such as design) is thus a relatively new phenomenon, but as will be explained further below it has already changed the way in which buyers and suppliers interact.

7.2.2 Co-design in the Indian software industry

The software industry is of course inherently solutions oriented, but co-design (as it is done today) is also a recent trend. The practice of body-shopping started in the 1980s but did not involve co-design at all since supplier staff worked within the buyers' premises on systems entirely designed by the buyer. This practice is still widespread but decreasing. In the 1990s many buyers adopted the so-called offshore model in which the bulk of the project is accomplished at the suppliers' offshore development centre on the basis of tight specifications provided by the buyer. While this includes usually some element of design, this is confined to low-level design. However, as lead firms proceed with more advanced sourcing strategies the separability of higher-order design processes and downstream programming tasks becomes increasingly difficult and buyers outsource elements of system definition as well as implementation. This means that the organisational decomposition takes the form of ODIP Type 4, in which implementation and requirement definition are bundled within the supplier's domain. Suppliers are engaged not only to create software artefacts (implementation) but also to co-define requirements. In other words, there is a tight connection between producing and innovating.

Co-design is on the rise in the so-called secondary software industry, that is the IT departments in large manufacturing and service organisations. An example is Volvo IT, the in-house IT division of Volvo, the European auto manufacturer of trucks and buses. In 2001, the Volvo group acquired Renault Trucks and Mack Trucks and all IT services divisions were consolidated in Volvo IT, which had become a wholly owned subsidiary. The new organisation was to play a new role, offering its services in the international marketplace for software development services. In the same year, the organisation initiated a competitive-sourcing programme and established relationships with suppliers in Poland and India, in order to reduce costs, speed up deliveries and learn from skilled partners. The outsourcing practice grew rapidly and the customer base expanded beyond the capacity of the

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27 However, it is important to add that the development of an engineering unit to provide co-development services represents a (high) fixed cost for a manufacturer of auto-parts. Therefore, there is a size threshold to the sustainability of engineering activities, which leaves most of the small parts manufacturers compulsorily out of the game.

organisation; it was therefore clear that a strategy of internal competence transition was needed. This strategy had two main elements. First, Volvo IT needed to establish a new role for the organisation, one that was closer to the customer and with more of the deliveries managed by suppliers. Second, it needed internal employees to move up the value chain: 'out of the technical areas and over to the business side of things' – in the words of the head of global sourcing.

Over time, the Indian supplier MindTree has become closely involved in the outsourced projects, including complex tasks in the software development life cycle. It no longer merely develops systems to Volvo's specifications, but also participates in the development of those specifications by finding resolutions to user requests. In many cases, the buyer needs to draw the supplier into the 'vision' of the project because of the limited ability of buyers to codify requirements at this stage.[28] These requirements are defined collectively based on the knowledge that each firm brings to the table. For instance, MindTree was able to draw on its experience of developing CRM systems for customers in other industrial domains and could use this 'generic knowledge' in the Volvo project. This type of division of labour is typical for distributed projects in the context of organisationally decomposed innovation. The two companies approach the requirement-definition phase from two different ends. The buyer's core competence is typically in the user domain (automotive industry in this example) and in the relationships with end-users. The supplier typically has previous experience of building different types of generic solutions (e.g. CRM, ERP, MIS) on a variety of technology platforms. Working together from these two different ends, solutions are designed collectively, drawing on distinct competence profiles of the firms.

In the software industry, co-design arises because of 'system ignorance', at least in the key initial stages of software projects. Either the design is not worked out yet at the point in which the supplier is engaged or the design is impossible to work out until the system is complete. At the initial stages the buyer and the supplier will deploy 'software architects' but as emphasised by Piore (2004) 'architecture is more like a living organism' in software, very unlike a builder's blueprint. Software projects are non-repeatable by definition and high-level architectures are fluid. This contrasts with the auto-industry in which high-level architectures are relatively fixed and design changes more bounded within this structure. Nevertheless, vehicle design is becoming increasingly complex as the technology develops and there are still key interdependencies in vehicle design architectures as changes in one component will have knock effects on other components (Novak and Wernerfelt 2006).

7.3 The nature of knowledge centred interaction

7.3.1 Knowledge centred interaction in the Brazilian automotive industry

The increasing complexity of design in the automotive industry and the shortcomings of codification efforts mean that buyers and suppliers in the Brazilian automotive industry have formed closer relationships in recent years. This differs

28 The 'vision' is a key artefact produced during the problem identification/inception stage of software projects.

markedly from earlier decades when the automotive industry in Brazil was almost exclusively a manufacturing operation. Assemblers and OEM suppliers located in the country used product and process designs elaborated by their respective headquarters. Some Brazilian national suppliers also entered the chain, based on product/process designs licensed from MNC suppliers.[29] Under such circumstances, there was little innovation activity in developing country sites (in both assemblers and their OEM suppliers) and therefore little need for co-development with locally owned suppliers and engineering services providers. The same applied to the interactions between assembler subsidiaries and Brazilian national OEM suppliers, which drew on product licenses. When product and process development is almost exclusively located in developed country R&D centres, knowledge flows are unidirectional from headquarters' R&D towards developing country subsidiaries, for both assemblers and key suppliers. However, ODIP changes this pattern as seen in the sampled firms. The flow of technical information has become thicker and more diversified as a share of product development has been relocated in Brazil – in the first decade of the new century. The exchange of codified and tacit knowledge has become strong and *bi directional*.

7.3.2 Knowledge centred interaction in the Indian software industry

This trajectory observed in Brazil is not unlike that of the sampled suppliers in the Indian software industry. To be sure, information exchange between Indian firms and their customers extended well beyond price and requirements already in the 1990s. Large amounts of information flowed back and forth. Multiple site visits in the early 2000s confirmed that offshore development staff had online access to the customers' information repositories and were able to retrieve 'real-time' design specifications, appraisals and other production related information (Lema and Hesbjerg 2003). The linkages between local firms and their customers, however, could not appropriately be described as 'thick' and based on tacit knowledge. All projects were made to highly specified requirements and were delivered with detailed codified documentation, enabling other firms to fix and develop the software further if and when needed. Because of the limited degree of tacit knowledge embedded in most of these relationships 'switching costs' were reduced (Lema 2009a: 70). However, this changes once specifications and design are co-defined. This is an interaction-intensive process characterised by high complexity and tacit knowledge. The buyer–supplier interface is therefore substantially thicker in this type of project, compared to implementation projects in which processes are easy to codify. In end-to-end CAD outsourcing, the project-based relationship is typically of a long duration in which the engagement period can last several years. Certain phases tend to be face-to-face intensive and suppliers often post personnel to the buyer premises on a semi-permanent basis. Thus, in most cases, software analysts and architects are stationed at the customer's premises. Together with the customers, they plan the overall design of

29 This was the initial experience of Arteb, Lupatech, Fras-le and Sabó, as presented in section 4. It was also the initial experience of firms like Metal Leve and Cofap, which were pioneers in terms of upgrading innovation capabilities to the advanced level. As seen in section 4, Metal Leve and the piston rings division of Cofap were eventually acquired by Mahle, whereas the shock absorber division of Cofap was acquired by the Brazilian operation of Magneti Marelli.

the system and the underlying project. In Volvo IT they have asked MindTree to post their customer account manager within the Volvo IT organisation and this manager has an office literally next door to the head of global sourcing in Volvo IT. While this is an exceptional example, there is a clear tendency to increase the investment in relationship management.

Our case studies thus provide some insights into the characteristics of relational linkages (Gereffi *et al.* 2005) in the context of the global decomposition of innovation activities. Some of the literature expects durable ties to be a prerequisite for these types of linkages. However, the interviews suggest that transfer of tacit knowledge is episodic and bounded in time and space. In the software outsourcing industry, it is achieved by establishing offices near the customers and/or frequent air travel and video links. While it is true that inter-organisational learning is more difficult in an international context than in a purely domestic setting – due to geographical and cultural distance – the difficulties seem to be diminishing. Return migration (Saxenian 2004; Vang and Overby 2006) does not seem to play a major role. While international working experience and cognitive affinity is important, there is no evidence of return migrants playing an important role in the sampled innovative projects.

7.4 Suppliers replicating external ODIP

We found that suppliers are replicating external ODIP in their own countries which is important for understanding the depth of the redistribution of innovation activities. Particularly interesting is that they are using university research competence in order to complement their own.[30] The challenging mandate from their customers induces the suppliers to do so. In this respect, the Brazilian case has given more findings than the Indian case. It thus follows the identified pattern in which the automotive industry follows an ODIP path that has more organisational layers (see section 7.1).

One of the most interesting knock-on effects of ODIP, which came out as findings from the Brazilian case, is local suppliers replicating ODIP as a consequence of the challenges they face due to having entered the co-design chain. Arteb, Lupatech, Sabó and Fras-le are sampled firms that have turned to Brazilian universities in order to source the research capacity that they lacked internally[31] (ODIP type 3). Lupatech and Sabó have gone further and explored patented inventions which have been developed by Brazilian universities. This suggests that local research institutions have had an important role, at least in the initial phases of ODIPing, in which local firms are climbing the ladder from NPD capabilities to technological research capabilities.

30 The national suppliers which managed to master high-level product development activities (Arteb, Lupatech and Sabó) and the few MNC subsidiaries which have become centres of technological competence (Mahle and Sachs), have significantly drawn on cooperative arrangements with Brazilian universities to compensate for their lack of technological infrastructure and internal research capabilities.

31 The major programmes of collaboration for technology support and advanced product development comprised: Lupatech with Materials Science Lab of UFSC; Arteb with Unicamp and UFSCar; Sabó with Unicamp, UFSCar, IPEN and CTA; and Fras-le and UFRGS.

It is important to add here that – over time – such Brazilian owned suppliers underwent significant changes in their sourcing of technological knowledge. Our case studies show that technology transfer from a foreign company – either in the form of a license agreement or in the form of a joint venture – was the common starting point in every case (Quadros 2009). Yet, these four Brazilian suppliers have progressively turned to relying more on their own technological experimentation and NPD learning than on technology transfer. In this trajectory, sourcing knowledge and R&D skills from universities seems to have been a critical decision.

These university centres were able to engage in contract research for the auto-parts industry because of their own history of accumulating capabilities in very specialised fields such as materials engineering (comprising metals, polymers and tribology), mechanical engineering, chemical engineering and metallurgy. And local suppliers look for their contribution in order to overcome their technology knowledge limitations. The typical situation is one in which problems arise either from the need to improve and adapt components or from new technology development. Solutions require technological knowledge, which is currently beyond the capabilities of the firm’s product development team. Thus, in such contracts research groups work as if they were a supplement to the R&D corporation lab.

7.5 Conclusion

In order to understand how ODIP affects the build-up of innovation capabilities in Brazil and India, this chapter sought to understand the process – and not just the result – of decomposing the innovation process. We have seen substantial differences between our two cases – mainly due to sectoral differences rather than country differences. In the automotive case, there is a sequential pattern of intra-company cross-border ODIP first, followed by inter-company country-internal ODIP. The local auto-parts suppliers in Brazil tend to link up with the Brazilian subsidiaries of multinational assemblers or first-tier suppliers. They are not directly associated with the initial ODIP. Moreover, such local suppliers have been increasingly turning to research collaboration with local universities in order to source scientists and laboratories which can strengthen their NPD and technological innovation capabilities. In India, local suppliers typically deal directly with buyers located in Europe or the USA and are directly affected by their ODIP decisions.

While the process differs, the outcome for local suppliers is the same. In both cases, they become deeply involved in co-design. In both cases, this has occurred through a transformation of relationships with their customers. Information flows have become thicker and bi-directional, both sides bring tacit knowledge to the table. The innovation is often the result of integrating the customer’s vertical and the supplier’s horizontal competency.

But innovation does not follow automatically. ODIP creates an opportunity for suppliers; it opens up a space which suppliers can occupy. Taking advantage of this opportunity and occupying this space is only possible for suppliers who have already accumulated certain capabilities and are able to make the required investments in people, equipment, organisation and relationships. In other words, the new innovation capabilities – if they do arise – cannot be attributed entirely to ODIP. Other ways of building capabilities – prior to ODIP – played a role. Quantifying their relative contribution is never possible but understanding the dynamics which lead to the build-up of innovation capabilities is possible. The next chapter takes us a step further in that direction.

8 Directions of causality and contingent factors

The core question of this research is whether and how the organisational decomposition of innovation in Europe and the USA influenced the deepening of innovation capabilities in the two industries in Brazil and India. The case material from both Brazil and India suggests that there is a strong connection between ODIP and innovation capability even though it is impossible to quantify this influence. This section reflects further on the causal connection, highlighting contingent factors and questioning the direction of causality.

In section 8.1 we suggest that the influence of ODIP in the old powers on innovation capability in the new powers was not automatic. It depended on a concurrence of circumstances. On the 'supply side' in Brazil and India it depended centrally on deliberate effort and investment in innovation capability.[32] This was a key contingent variable which is important to include in a comprehensive discussion of how ODIP 'worked'.

In section 8.2 we go a step further and suggest that ODIP only created new opportunities where previous capability building had already occurred. This point is not trivial. It raises questions about the direction of causality between lead firm ODIP practices and the formation of capabilities in subsidiary units and supplier firms. Our key point is that the direction of causality is not one way. Our interviews suggest that capability building in Brazil and India seems to have affected ODIP decisions in lead firm headquarters. Initially, the emerging availability of credible and technologically competent partners and subsidiary firms in Brazil and India contributed to ODIP as a viable practice. Over time, the strengthening of capabilities (reinforced by ODIP) played a key role in deepening and accelerating the process. In short, the causal relationship is not only circular, but also cumulative.

These elements of the analysis extend the focus beyond the core question of our paper. We cannot examine the circular nature of causality to the full extent, nor can we examine the entire multitude of contingent variables that influence the relationship between ODIP and capability building. Rather, our aim in this chapter is more modest: to provide insights from the case studies regarding the factors which seem most important. This qualifies some of our main arguments in this paper and it opens up interesting avenues for new research.

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32 On the 'demand side' it depended centrally on factors discussed earlier: changes in innovation strategies and lead firm restructuring.

8.1 Turning opportunity into reality

The main argument in this section is that there is no automaticity in ODIP generating innovation capability. The interviews suggest that deliberate effort and investment is required in order to exploit the opportunities opened up by ODIP. Such active efforts affected the firms' and subsidiaries' ability to exploit the market spaces and learning spaces opened up by ODIP. In the course of addressing these opportunities the firms further invested in and benefited from the leveraging of capabilities with multiple customers inside and outside the country.

8.1.1 Internal investments in people, equipment, organisation and relationships

While ODIP opened up opportunity spaces, the exploitation of these spaces depended on investments in capability. This required internal investment in assets such as people, equipment, organisation and relationships.

In the Brazilian sample firms such investment was substantial. As an example Fras-le created its own R&D lab which it organised and staffed, stepping up R&D investment and speeding its learning process. On average, Fras-le spent 3 per cent of net revenues in R&D annually, in the past four years prior to fieldwork. Similarly, Metal Leve, before acquisition by Mahle, invested heavily in building laboratories, hiring and training engineers and researchers. Already in the early 1990s, Metal Leve's R&D staff totalled 230 professionals. This helps explain technological learning in Metal Leve and the success first in exports, and later as an international producer.

The typical situation in which concrete instances of learning unfolded was one in which an improvement in a given component requires technological knowledge, which is currently beyond the capabilities of the firm's product development team (either in a national or multinational corporation). Central labs are often too busy attending to the corporation's priorities and cannot afford to dedicate the time the Brazilian subsidiary requires. In the case of Brazilian national suppliers, the explanation is similar, with the difference that there is no central lab to turn to and problems arise either from the adaptation of licensed technologies or from new technology development, as illustrated in the cases of Lupatech and Fras-le in this research. Such active efforts of investing in learning and sourcing knowledge was important for exploiting the new mandates and spaces.

In the Indian software industry, Lema (2009b) suggests that learning from lead firms and buyers was important but insufficient alone. Innovation capability formation depended on other channels and mechanisms outside and/or independent of outsourcing relationships. Supplier firms drew significantly on their own resources in order to innovate. Although buyer firms were involved in creating new spaces they were only partially involved in providing the critical inputs for their exploitation – and in any case this provision of inputs was necessary but not sufficient for capability building. Exploiting new spaces involved significant *active* effort in supplier firms that often worked through channels that were independent of outsourcing relationships.

Examination of innovation events in the Indian firms showed that in many cases, the sources of knowledge were results of traceable investment decisions made by management or dedicated innovation groups/initiatives. The latter includes investments in such things as the creation of new artefacts (concept papers, proof of concept models), in training and hiring of recruits with specialist skills and/or in the facilitation of workshops, special interest groups, etc.

In the services space, some firms have established and invested in dedicated R&D units but overall they tended to rely on other forms of knowledge creation. InFlux in Infosys (see section 5.2.3) was based on activities undertaken within SETLab (Software Engineering and Technology Laboratory), the main R&D department in Infosys. However, as is typical of business process software services (BPSS), this was a fuzzier version of R&D activity (Miles 2007).[33]

8.1.2 Learning with multiple clients

Investment in innovation assets was seemingly a central contingent variable that needed to be in place for ODIP to unfold.[34] However, our circumstantial evidence also suggests that further investment and effort was necessary. Particularly important was active management aimed at integrating competences from across distinct customer business units. In effect, the firms managed to leverage competences across multiple clients, in particular overseas clients.

In Brazil, the expansion of auto suppliers *abroad* helped these firms to exploit ODIP at *home*. In other words, the increasing international presence of the suppliers observed for this research seems to have gone hand in hand with their mounting role as providers of innovative solutions. As we shall explain, there are several reasons for this.

The Brazilian case studies show that the degree of internationalisation is a variable that helps to understand the differences in the innovation capability evolution of the suppliers controlled by Brazilian nationals. The national suppliers who have advanced most in innovation capabilities are the ones whose growth strategies include the global market: Sabó, Lupatech, Arteb and the Randon group (particularly in the case of Fras-le). By mobilising financial, human and institutional resources in order to develop the innovation capabilities required to compete globally, these firms have undergone not only a process of technological learning but also of business learning. Arguably, it is this type of increased business understanding combined with technological competence that provides a passport to ODIP.

However, internationalisation is also necessary in relation to ‘filling’ the spaces created by ODIP. In the case of Mahle Metal Leve, the customer in Germany (BMW) required that the Brazilian supplier sought collaboration with European and North American universities with which BMW have had experience in partnership in the specific field. This poses a new type of problem regarding the involvement of Brazilian research institutions in ODIPing processes driven by MNCs. To what extent do R&D networks built by MNC headquarters and involving research institutions in Europe or the US, constitute a barrier to their subsidiaries’ building

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33 Product development software services firms (PDSS) tend to depend more on R&D.

34 In conceptual terms, the emphasis on investment in learning is relevant to note in relation to the general idea of ‘taking advantage’ of the opportunity opened up by ODIP. Exploiting this opportunity requires the supplier or subsidiary to have a significant element of the capability for undertaking the activity.

R&D networks with local research institutions? The fact that most Brazilian subsidiaries which have extended mandates to include R&D activities are engaged in NPD, but not in technological research, would suggest that this tends to be a limitation difficult to be overcome. R&D in such subsidiaries is usually carried out by NPD engineers with little research training. Even when they are interested in establishing links with local research, they may fail for lacking the necessary knowledge to approach scientific institutions.

Internationalisation was also important in the Indian software industry. While the methods of internationalisation have differed to some extent, the capturing of innovation spaces has been closely associated with the very concrete efforts of internationalisation, as is apparent in many of the innovation events. The development of new capabilities has arguably also been dependent on increased global presence. The largest companies have become global corporations that can match the global presence of their customers. The importance of such linkages has driven foreign investments and the acquisitions by foreign firms. Acquisitions were often major enablers in the innovation processes behind the events examined for this research. Knowledge brought in from the outside often made a significant contribution; it would have been difficult to develop it in-house or without close linkages to technology shapers.[35]

More broadly, the software case suggests that cross-border linkages (as opposed to overseas investments) gave rise to competence leveraging which utilised the multi-client environment in which ODIP unfolded. Lema (2009b) distinguished explicitly between (i) the emergence of new opportunity spaces, and (ii) the processes by which suppliers 'mobilise' and combine resources to fill them. The material suggests that the integration of internal and external inputs for addressing new spaces was not trivial. The *combination* of external and firm-internal as well as buyer/client-driven and 'other' inputs/resources was critical and tended to go hand in hand in the learning process. This blending process is inevitably one that occurs within firms in the supply base and one that needs to be *actively* managed. The changing demand conditions and reconfiguration of value chains did not transpire into a 'benign escalator' for supply-base firms.

Indian suppliers learnt to continuously cross-feed knowledge and experience from one project to another through the implementation of comprehensive knowledge management systems. These software firms became project based organisations, able to enter continuous cycles of extraction (harvesting), development and application of knowledge in projects in the same area. However, learning over time was augmented by a particular dynamism arising from the leveraging of competences *across* projects situated in different vertical knowledge domains (for

35 In the context of ODIP, there are two aims of the internationalisation process that are particularly relevant, the development of *relational capabilities* and the deepening of *technical knowledge* and capabilities. Both of these are associated partly with *fluid internationalisation* based on air travel and the temporary shift of base for leading projects staff. This was discussed as 'the nature of knowledge centred interaction' in section 7.3. However, the largest suppliers have gone beyond this with *permanent internationalisation* through greenfield FDI (typically market-seeking front-end offices in OECD countries) and overseas acquisitions (such as Infosys's competence-seeking acquisition of Expert Information Services in Australia).

example, the automotive industry or the financial industry) and horizontal knowledge domains (different types of IT systems such as ERP or CRM software). This combination of knowledge gave the Indian firms an advantage in supplying innovative services in the global market. They do not dilute their core capabilities by operating in multiple business lines; rather the leveraging of knowledge and experience across these business lines became a core capability in itself.

8.2 Directions of causality

In this section, we extend the timescale to show that significant capabilities existed before or simultaneously with the changing lead-firm practices.[36] This raises the question of whether and how this build-up of capabilities in Brazil and India has induced ODIP on the part of lead firms in the Europe and the USA.

8.2.1 History matters: capability building before ODIP

Any understanding of 'ODIP causality' is significantly influenced by the timescale that is considered. This subsection starts by going back in time and emphasises the pre-existing capabilities in Brazil and India before ODIP began to unfold. The effects of ODIP decisions taken in the US and Europe did not parachute onto virgin territory in Brazil and India. Rather ODIP was a key mechanism of adding to and deepening capabilities in the two industries in Brazil and India.

Extending the time period helps to grasp the dynamics and direction of causality between organisational decomposition and the formation of capabilities. Most cases of capability building in the Brazilian auto-parts industry are stories of 25 years or more of gradual learning and accumulation of design competencies (Quadros 2009).[37] Drawing on chapter 5, it is interesting to note that, in the early 1990s, most firms of the sample had already attained the capability of carrying out application development. Sabó had already mastered variant development. Also the MNC's subsidiaries investigated benefited from previous processes of technological learning that occurred under previous national ownership.[38] From this perspective it seems plausible that the previous innovative capability attained by the sample firms motivated MNCs to extend ODIP to Brazil.

All seven firms in the group of advanced innovation capabilities have gone through long trajectories of technological learning and undergone previous stages of technological capabilities. Some, as in the cases of ArvinMeritor (formerly Rockwell), Bosch and ZF Sachs, are MNC subsidiaries that, since the 1980s, have systemically pursued capabilities in new product development and increased their product engineering areas. They have started by searching for incremental product changes, mostly designed to meet local market needs: adapting

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36 This suggests that ODIP is potentially a channel for adding to *existing* capabilities in subsidiaries and suppliers in India and Brazil. This is to be contrasted with the *creation of* capabilities. We suggest that ODIP facilitated the deepening (not the creation) of innovation capabilities.

37 There are only three exceptions, Letande, Freios Master and Suspensys.

38 We refer here to the cases of ArvinMeritor/Rockwell-Braseixos, ZF Sachs/BorgWarner and Mahle Metal Leve.

components to requirements of local biofuels or using local minerals for new formulations of friction materials. In the case of Mahle Metal Leve, the foreign corporation (Mahle) which has taken over the well-known Brazilian suppliers of power-train components Metal Leve and Cofap, benefited from their two decades of gradual building of capabilities. Moreover, the basis of knowledge and capabilities acquired from Metal Leve and Cofap has been the platform on which Mahle has raised its Brazilian Technological Centre, which is one of the five centres of Mahle’s global R&D network.

The same applies to the Brazilian national suppliers. Sabó has reached its current level of capabilities after decades of capability building. In the early 1960s, Sabó set about creating its own R&D lab. In the 1970s, the company dedicated engineering efforts to design mechanical equipment to be used in manufacturing, thus developing competencies in metallurgy and mechanics, which was revealed to be critical when the decision was taken to develop proprietary products to supply European customers. This was a critical resource behind its internationalisation trajectory.

Even though it is younger and smaller than Sabó, Lupatech has also systemically pursued moving up the ladder of innovation competencies, since its foundation in the early 1980s. Lupatech’s trajectory started with the transfer of foreign steel powder injection technology. However, in the 2000s Lupatech invested substantially in developing a new, proprietary sintering technology, with support from Brazilian university research. This move was important to differentiate its services, and helped open up the North American automotive market for Lupatech. In addition to the Brazilian plant, Lupatech operates plants in Argentina and the US. Arteb, the Brazilian supplier of light systems, has had a similar trajectory up to reaching the level of developing proprietary process technologies, in the 2000s. From its beginning, in the 1950s, Arteb has counted on technology transfer from Hella, the German supplier of lights. This was a long-term partnership, since Hella licensed the VW Beetle lights to Arteb and acquired a small stake in the Brazilian supplier. After investing continuously in product/process technology learning, Arteb attained the competencies to develop incremental product changes and advanced process changes. In the early 2000s, prompted by the opportunities opened up by North American customers (GM US, for instance), Arteb decided to abandon the technology license agreement with Hella, which hindered its entry in non-Latin American markets. In order to compensate for this, Arteb stepped up its R&D activities, by creating its own and independent Arteb Technological Centre.

A remarkable point in the cases above is that the building of innovation capabilities has been concentrated in a few technological domains, the most significant of which are materials engineering (comprising metals, polymers and tribology), mechanical engineering, chemical engineering and metallurgy.

This longer term perspective (taking account of a period of 20 or 30 years) underlines that the building of innovative capability was a process that started *before* the introduction of decomposed innovation practices by lead firms. It also suggests that this prior learning played a role in the decisions of MNC assemblers and suppliers to involve Brazilian subsidiaries and national suppliers in innovation activities.

Few studies of the Indian software industry have traced the evolution of the industry back to its roots. The few studies that adopt a historical perspective are primarily concerned with the policy dimension (Evans 1992; Heeks 1996; Lema and Hesbjerg 2003). However, it is interesting to note that the current giants of the industry – Infosys, Tata Consultancy Services, Wipro – are also some of the oldest firms in the industry and they have all been producing software for more than 30 years. Infosys is a little younger (established in 1981), but this firm was founded by a breakaway group of Patni Computer Systems (established 1979), one of the early private sector players. While most initial software development activity in India was undertaken in the public sector,[39] the initial software development capability in the current giants grew out of demand from the Indian private manufacturing sector. Both Tata and Wipro were industry and trade conglomerates; and software development arose in services units catering for the IT needs of the manufacturing arms of these industry houses. Only later did they begin to address software demand from other customers.

The work of these firms outside India began with 'body-shopping', i.e. the transportation of software professionals to work at the buyer's premises overseas. In the late 1980s, body shopping was the primary mode of software exports. The managers of Indian software firms interviewed for this research pointed out that this mode of software outsourcing was very conducive to fast customer-oriented and problem-focused learning. While often frowned upon as low value-added work, the onsite 'body-shopping' model that characterised software 'outsourcing' in the 1980s gave Indian suppliers access to opportunities for an in-depth understanding of required customer needs, project management practices and business routines and pressures. While many sectors in developing countries have been disadvantaged by a lack of access to tacit knowledge about required products/services and organisational best practices in lead markets (Altenburg 2006), this did not apply to the Indian software industry. It is sometimes overlooked that there was a continued substantial presence of Indian software professionals working onsite in customer markets, even as more work was shifted offshore to India during the 1990s. There is still a presence of onsite personnel, but it has taken on a new knowledge-creating role.

From a learning perspective, the Indian software industry of the 1990s can be divided into two segments. The first and largest segment was devoted to the development of software to customers' specifications (services). The second and smaller segment was concerned with the development of own software packages. This did not thrive because Indian firms did not have the skills necessary to make products that were commercially viable in the international market. Unlike the services segment, they were detached from advanced users. In the 2000s they therefore began to address the independent software vendor market by offering their development capabilities instead. Their line of business became known as outsourced product development (OPD) and they could draw on capabilities

39 The first large scale software projects in India were public sector undertakings originally dealing with computer hardware, such as Electronics Corporation of India Limited (ECIL) and Computer Maintenance Corporation (CMC). These were part of a very small number of firms with software activities in India in the late 1970s – the time when IBM was 'forced' out of India due to new equity rules. Only a few computers were allowed to be imported and most of them were from the Soviet Union. CMC had a monopoly on the servicing of these foreign systems. However, unlike joint ventures such as Tata-Boroughs, these state-run firms did not scout for the export markets.

acquired from previous experimentation with product development. In this sense, the supply side contributed to new types of outsourcing (or rather the outsourcing of new functions) in this segment. [40] More generally, such learning on the part of Indian firms contributed to ODIP which in turn opened up new possibilities for acquiring innovation capabilities.

While this paper has not concentrated on the historical evolution of these two industries, the above observations highlight the need to go further back in time if we want to establish causal connections between ODIP in OECD countries and capability building in Brazil and India. ODIP only created new opportunities where previous capability building had occurred. More detailed historical research would need to examine whether one can go as far as distinguishing an 'initial and igniting feedback effect', to be contrasted with a 'later and deepening feedback effect'. While the emergence of ODIP is rooted in a myriad of factors that are difficult to untangle, it is easier to specify the feedback effect in the deepening of ODIP. We discuss this next.

8.2.2 Circular and cumulative causation

The observed learning over time is significant for the main question addressed in this report. Add to this the observation – arising from both the auto and software case material – that lead firms sometimes 'take what's on offer'. In combination, these findings suggest that the unfolding of ODIP was not a one-way street. It was not only influenced by general changes in business strategy and innovation practices in lead firms, but also by the development of increasing innovative capability in the supply base. As discussed above, the increasing capabilities in subsidiary and supplier firms in Brazil and India contributed to the emergence of the ODIP strategy. Over time, it then deepened and accelerated the ODIP process, reinforcing the initial impulse. This means that the causal relationship was not only bi-directional (or circular), it was also cumulative.[41]

Much of the literature on offshoring/outsourcing by multinationals and lead firm buyers tends to assume (often implicitly) that the impetus comes from the demand side. Buyers make decisions about location of innovative work, whereas subsidiaries and suppliers merely respond to these decisions. While it is true that lead firms ultimately decide whether and to what extent innovative tasks are located in low-cost economies, our research suggests that the supply base has an important influence on these decisions.

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40 Take the case of the ETL tool that was developed by Aztecsoft but acquired and marketed by California-based Embarcadero Technologies. The buyer was not actively seeking to expand its product portfolio but was unexpectedly offered this product. After the transfer of the license, the two firms initiated a relationship akin to own design manufacturing (ODM). The buyer became responsible for sales and marketing whereas the supplier became responsible for product roadmap development and all technical and managerial functions related to subsequent versions of the product.

41 Swedish economist and Nobel laureate Gunnar Myrdal coined the 'term circular cumulative causation' in his seminal work 'The Asian Drama'. He suggested that: 'circular causation will give rise to a cumulative movement only when [. . .] a change in one of the conditions will ultimately be followed by a feed-back of secondary impulses [. . .] big enough not only to sustain the primary change, but to push it further. Mere mutual causation is not enough to create this process.' (Myrdal 1968: 1875)

In the software industry, interviews with buyers indicate that these supplier capabilities mattered. The case material indicates that the adoption of open business models by buyers and the resulting outsourcing of innovation activities were directly influenced by the attainment of general and customer specific capabilities by suppliers. The data show that increasing capabilities and competence leveraging (as described above) had important feedback effects. Some of these feedback linkages were direct and relationship specific. Others were indirect, affecting the incentives for outsourcing in general and opening up new options for offshoring advanced activities in cost-effective ways. This 'own' dynamic not only accelerates outsourcing, it also changes the very notion of what outsourcing is about. It has induced immense organisational change whereby lead firms have been rethinking mission statements and operating models.

It helps to distinguish between direct and indirect feedback mechanisms. *Direct feedback* mechanisms transmit in a straight line between suppliers and buyers, as the former develops customer-specific competences and the comfort levels of the latter rises. This widens the range of options for further outsourcing at the unilateral level. *Indirect feedback* mechanisms are the external effects of increasing supplier capabilities at the multilateral level. These create new options for the 'demand base' as a whole. This means that openness and outsourcing that are initially practised by only a few firms may therefore set in motion a co-evolutionary process, in which supply and demand are recursively moving towards higher-level, more advanced innovation activities at the aggregate level.

Lema (2010) discussed buyer business models and their 'opening' and argued that such openness was not only driven 'from above'. Buyers, when defining their business model, were significantly influenced, by the changing outsourcing landscape in Bangalore. In some case studies, respondents' information suggested that the opening of business models were directly influenced by the attainment of general and customer specific capabilities by suppliers. This was particularly important when shifting gear in business model opening. The supply side dynamics and issues related to linkages and trust were particularly important in cases of 'advanced' outsourcing in a 'second stage' of openness.

Similarly, in the research on the Brazilian automotive industry, Quadros (2009) suggested that learning has an important implication for the understanding and theoretical modelling of ODIP processes because it suggests that not only the dynamics in OECD countries influences ODIP. Also the endogenous processes of technological learning, which happen in countries like Brazil, have an influence on the decision-making processes at firm level related to ODIP. The increase in the general capability level is forging an attractive environment for ODIP in Brazil. An important conclusion that comes out from this case is that the forces, the momentum and the learning processes from the South are as important as is the momentum from the North.

In the initial set-up of the questions about ODIP addressed in this paper, the role attributed to MNCs as drivers of ODIP was emphasised. This reflects the fact that the Brazilian industry is now much more internationalised than it was 20 years ago. Yet, this research suggests that the long process of accumulating capabilities in both Brazilian subsidiaries of MNC suppliers and Brazilian national suppliers has been a critical factor in explaining their increasing importance in the global value chain.

It is more than their response to the ODIP moves coming from MNCs' headquarters or subsidiaries in OECD countries. The contribution of Brazilian MNC subsidiaries and of Brazilian national suppliers to ODIP starts before the ODIP movement from the OECD country firms and goes beyond such movement. As the material suggests, the entry of Brazilian subsidiaries in their corporations' global R&D networks has not happened as a decision from headquarters in order to build innovation capabilities, but the other way round. In the cases of Bosch, Mahle Metal Leve and of ZF Sachs, Brazilian subsidiaries' innovation capabilities have developed over a considerable period of time, and before the model of a global R&D network had diffused. Their attainment of a certain level of technological competency has been critical for them to be recognised as significant assets in a globalising economy.

8.3 Conclusion

In this chapter we suggested that innovation capability building and deepening is not an automatic outcome of ODIP. ODIP created a space but the effective exploitation of that space involved a significantly active effort on the part of firms in India and Brazil. We also suggested that the causal connection between ODIP is not one way. In fact, it is difficult to pinpoint where it all started. We suggested that technological learning and the formation of innovative capabilities preceded or concurred with the decomposition of innovation by lead firms in both sectors. The decision-making process in lead firms is not only guided by pressures and opportunities in OECD countries but also by the new innovation capabilities that have been developed in Brazil and India. In this way, the suppliers and subsidiaries have been important in accelerating ODIP and the global redistribution of innovation capability.

9 Conclusion

This final chapter summarises the main findings, indicates advances to the literature and reflects on the future distribution of innovation activities between old and rising powers.

9.1 Summary of findings

The main findings emerging from our in-depth research on the Brazilian auto industry and Indian software industry are as follows.

- **Dynamics of change.** We started with the recognition that a shift in the distribution of innovation power from the old powers to the rising powers is underway and that many factors have contributed to this shift. Most of the literature has concentrated on the factors within the rising powers. This report has examined how the old powers themselves are contributing to this shift. It concentrated on the organisational decomposition of the innovation process (ODIP) in Europe and the USA and asked how ODIP has affected the accumulation of innovation capabilities in Brazil and India. In addressing this question, it provided new insights to the literature on the changing geography of innovation in the global economy (Bruche 2009; Ernst 2009; Fifarek and Veloso 2010; Mudambi 2008) by unravelling the dynamics of those changes which emanate from the old powers.

- **Advanced innovation capabilities in Brazil and India.** The literature on both the Brazilian auto industry (Cassiolato *et al.* 2001; Humphrey *et al.* 2000; Salerno *et al.* 2003) and on the Indian software industry (Arora 2006; Chaminade and Vang 2008; D'Costa 2009) has tended to be pessimistic with regard to the attainment of local innovative capability. This is not what we found. Subsidiaries and independent suppliers were involved in advanced innovation capabilities: they engaged not only in 'applied' development, but also in 'systemic' development of products and services. In the Brazilian auto industry, subsidiaries of multinationals and local suppliers have attained capabilities based on R&D. In the Indian software industry, foreign and local suppliers have proven capabilities in high-level design. Yet, much of this Indian innovation remains hidden and is overlooked in R&D-centric studies.

- **Time or method?** How can such contrast in understanding be explained? Do the differences between our findings and those of previous literature stem from the changes being very recent or are they due to distinctive research methods? It seems that both reasons contribute to the difference. Our research is based on a robust but intentional sample of the vanguard and thus it is not statistically representative either of the Brazilian automotive or the Indian software industries. However, our methodological choice of in-depth investigation of significant innovation events involving customers and suppliers has allowed the unravelling of new findings that so far have been overlooked. Second, this report and related publications (Lema 2009b, 2010; and Quadros 2009) have documented that the build-up of innovation capabilities in both cases has been accelerating in recent years. The real world is changing fast.

- **The importance of ODIP.** Explanation of the Indian and Brazilian advances in innovation capabilities needs to include ODIP and its effects. Lead firms headquartered in the USA and Germany have reorganised their value chains and delegated major innovation functions to their subsidiaries and to independent suppliers in Brazil and India. We examined how and under what conditions firms in Brazil and India have occupied the new spaces and the knock-on effects on their own value chains. In conducting this analysis we have sought to bring together three different strands of literature that have remained disconnected: The work on investment-centred value chains within MNCs (Chen 2008; Hobday and Rush 2007; Marin and Bell 2010; Saliola and Zanfei 2009); the literature on developing country firms in trade-centred global value chains (Ernst 2008; Giuliani *et al.* 2005; Morrison *et al.* 2008, Schmitz 2007); and the capability-centred work on developing country firms (Bell 1984; Ariffin and Figueiredo 2006; Figueiredo 2006). The ODIP framework provides a way of bringing these literatures together.

- **Making the ODIP typology work.** The findings can be grouped, distinguishing between internal ODIP (within the decomposing organisation) and external ODIP (delegating innovation functions to other organisations). We also distinguish between innovation functions that are either loosely or closely connected with production functions. This ODIP typology (proposed

Table 9.1 ODIP types in the Brazilian auto and Indian software industries

Internal – External / Connection between production and innovation	Intra-firm	Inter-firm
Loosely connected	**Type 1** Decentralising research departments; strengthening dispersed Centres of Excellence in research and experimental development; deepening subsidiaries' existing Type 2 mandates to encompass advanced product and process engineering **Moderate but growing** in both cases.	**Type 3** Commissioning research from specialised firms, universities or other organisations, contracting new technology development from specialised R&D organisations, collaborating with competitors in technology development 'clubs' **Moderate but growing** in autos and **weak** but gaining traction in software.
Closely connected	**Type 2** Delegating to subsidiaries mandates for the improvement or development of new products and processes; dispersing internal centres of design or engineering excellence **Strong** in both cases.	**Type 4** Engaging suppliers of products and services or specialised consultants to upgrade, develop and design new products or to contribute to process engineering **Strong** in both cases.

Source: Authors' own fieldwork.

by Schmitz and Strambach 2009) is used for summarising the findings in Table 9.1.

- **Big change in innovation closely connected with production.** As shown in Table 9.1, ODIP types 2 and 4 dominated. Organisational decomposition and geographical relocation occurred in innovation activities that were tightly connected to production activities. The Brazilian part of the global auto value chain is engaged in product and process design, not only for local or regional markets but increasingly also for global markets. When design problems arise in the course of ongoing new product development, they are tackled by subsidiaries or national suppliers in Brazil. In the software industry, lead firms offshore not only programming tasks, but also important elements of product and services development, including high-level systems development.

- **Less change in innovation loosely connected with production.** ODIP types 1 and 3 were less frequent and significant. In the auto industry, lead firms tend to keep corporate research units in the USA and Europe. In particular, the synthesis and integration of different knowledge domains – essential for defining technologies of the future – tend to stay in the USA and Europe. However, subsidiaries and national suppliers have engaged Brazilian universities in conducting research on new materials and products. In the Indian software industry, the subcontracting of local research centres is less common.

- **Replication of ODIP within the new powers.** Inter-continental ODIP has country-internal knock-on effects. This is clearest in the Brazilian auto industry. Brazilian subsidiaries which received an innovation mandate from their European headquarters, then farmed out part of the innovation process to their national Brazilian suppliers. National suppliers – engaged in product innovation for world markets – collaborate with Brazilian universities in research on specific new materials or processes. The inclusion of these country-internal knock-on effects was one of the reasons why we could record new divisions of labour in the innovation process which are not recorded in the previous literature.

- **What about strategic innovation?** In order to ascertain whether ODIP extended to activities that were strategic for the lead firms we made the distinction between problem solving and problem framing. The dispersal of innovation capabilities to firms in Brazil and India occurs mainly in problem-solving functions. Problem-framing capability is less mobile and tends to remain in the old powers. In other words, the new opportunities for foreign and national suppliers in Brazil and India remain bounded by the strategic concerns of corporate headquarters. However, the lead firms unintentionally set forces in motion that are beyond their control. In the course of dealing with advanced problem solving, some Indian software suppliers acquire capabilities for problem framing in technical fields which some US lead firms are beginning to draw upon. This means that earlier suggestions that the lead firms in global value chains will retain the strategic innovation functions (Schmitz 2007) need to be revised. We found that suppliers have acquired expertise that lead firms used to consider strategic. Clearly ‘strategic’ is a slippery concept, definable only by the lead firm. Nevertheless it is meaningful to record that – in the software industry – the lead firms’ strategic core lies increasingly in non-technical areas and customer-facing functions.

- **Contingencies.** The most innovative firms in both industries had two features in common. They had substantial histories of technological learning and continued to make substantial internal innovation-focused investments in people, organisation, relationships and equipment. This enabled them to capture the opportunities opened up by ODIP. Hence we do not suggest that innovative capability is an automatic outcome of ODIP. Far from it. There are contingent factors which determine whether the opportunities for dispersal opened up by ODIP are transformed into dispersing realities.

- **Reverse causalities?** The causal connection between ODIP in the old powers and increase of innovation capabilities in the new powers is not one way. The increasing accumulation of innovation capabilities in the new powers increases the possibilities for further rounds of ODIP in the old powers. It is, however, difficult to pinpoint where the whole process started. As stated above, the first round of ODIP was preceded by the accumulation of initial innovation capabilities in the rising powers. Whatever the starting point, a dynamic is underway of decomposing and recomposing innovation processes in the course of which major geographical shifts of innovation capabilities take place.

9.2 Reflecting on the future

The future evolution of ODIP and its implications for the build-up of innovation capabilities in the rising powers will depend on a multitude of factors which affect an increasingly complex and integrated global economy. Thus, it can only be a matter of speculation. Yet, considering the set of variables and determinants which have been addressed in this report, one could picture two polarised scenarios.

The first scenario is co-evolution of the old innovating regions in Europe and the USA and the new innovating regions in Brazil and India. Changes in one bring about changes in the other and vice versa. The division of labour changes, their specialisation profiles change but both move forward. The process is painful but the result is win-win. In this scenario, it is possible that the division of labour and specialisation will be more pronounced not only within sectors, but also between sectors.

Within the two sectors which we have investigated, it could well be that MNC's subsidiaries and local suppliers in Brazil and India will increase their role in ODIP types 1 and 3, that is, increase their function as providers of new technologies and raise their problem-framing capability. Such new innovation activities are likely to be concentrated in the technology and knowledge domains in which engineering and science in the new powers are particularly strong: materials science and biofuels engineering in the Brazilian auto industry, and exploration of new software languages in India. Further investments in these fields can provide the means for effective problem framing and solutions in the future.

In this first scenario, lead firms located in the old powers will draw heavily on their science power in order to lead major breakthroughs and industry rejuvenation. A good example in point, for the automotive industry, is the experimentation with electric vehicles, which has been pushed by lead firms and governments in the USA and Europe. Making such vehicles viable and developing the required infrastructure will depend on breakthrough technological and institutional innovations. Lead firms and governments are investing in such innovations not only for the sake of curbing CO_2 emissions, but also because they envisage a new frontier of economic and technological leadership.

The second scenario also stresses intense interaction but the result is that one side loses and the other one wins. The loser is the old region which sees a decline in innovation jobs and economic prosperity. The winner is the new region which sees a rise in innovation jobs and prosperity. ODIP plays a critical role in this process. ODIP leads to a hollowing out of the innovation capabilities of the old regions and a corresponding deepening of innovation capabilities in the new regions. In other words, by embarking on ODIP, the old regions are digging their own grave.

This scenario is less likely to happen, if we see the future as an extrapolation of the past. However discontinuity and rupture seem more likely. The economic stagnation and the political paralysis in most of North America and Western Europe contrasts with the economic growth and gain in confidence in the rising powers. Such diverging growth trends are bound to affect the location of innovation. Markets are predicted to remain flat in the old powers and grow in the new powers. We know that lead markets have a big impact on where innovation happens and what it is focused on. The sheer capability to invest in innovation is high and rising in the new powers, in both the public and private sectors. This contrasts with the high public indebtedness in the old powers and the patchy investment capacity in its private sectors. So from both an investment-push and a market-pull point of view, the new powers may be gaining and the old powers may be losing.

Only time can tell which of these scenarios captures real developments. It could be that neither prevails and that the outcome is highly differentiated, varying a great deal between sectors. This does not mean that everything is uncertain. It is clear from this study that ODIP benefits the rising powers. What is not clear is whether and where the old powers suffer as a result. Perhaps the biggest winners are the globalised firms which originate in the old powers but locate their innovation activities increasingly in the new powers.

References

Altenburg, Tilman (2006) 'Opportunities for Asian Countries to Catch up with Knowledge-Based Competition', in B.-Å. Lundvall, P. Intarakumnerd and J. Vang-Lauridsen (eds), *Asia's Innovation Systems in Transition*, Cheltenham UK ; Northampton MA: E. Elgar

Altenburg, Tilman; Schmitz, Hubert and Stamm, Andreas (2008) 'Breakthrough: China's and India's Transition from Production to Innovation', *World Development* 36.2: 325–34

Ariffin, Norlela (2000) *The Globalisation of Innovative Capabilities: The Malaysian Electronics Industry*, Brighton: Science and Technology Policy Research, University of Sussex

Ariffin, Norlela and Figueiredo, Paulo N. (2006) 'Globalisation of Innovative Capabilities: Evidence from Local and Foreign Firms in the Electronics Industry in Malaysia and Brazil', *Science Technology and Society* 11.1: 191–227

Arora, Ashish (2006) 'The Emerging Offshore Software Industries and the U.S. Economy', in S.M. Collins and L. Brainard (eds), *Brooking Trade Forum 2005: Offshoring White-collar Work*, Washington DC: Brookings Institution Press

Arora, Ashish; Forman, Chris and Yoon, Jiwoong (2008) 'Software', in J.T. Macher and D.C. Mowery (eds), *Innovation in Global Industries: U.S. Firms Competing in a New World*, Washington DC: National Academies Press

Asakawa, Kazuhiro and Som, Ashok (2008) 'Internationalization of R&D in China and India: Conventional Wisdom versus Reality', *Asia Pacific Journal of Management* 25.3: 375–94

Athreye, Suma S. (2005) 'The Indian Software Industry and its Evolving Service Capability', *Industrial and Corporate Change* 14.3: 393–418

Balcet, G. and Consoni. F. (2007) 'Global Technology and Knowledge Management: Product Development in Brazilian Car Industry', *International Journal of Automotive Technology and Management* 7.2–3: 135–52

Bell, Martin (2007) *Technological Learning and the Development of Production and Innovative Capacities in the Industry and Infrastructure Sectors of the Least Developed Countries: What Roles for ODA?*, Brighton: Science and Technology Policy Research, University of Sussex

—— (2006) 'Time and Technological Learning in Industrialising Countries: How Long Does it Take? How Fast is it Moving (If at All)?', *International Journal of Technology Management* 36.1–3: 25–39

—— (1984) ' "Learning" and the Accumulation of Industrial Technological Capacity in Developing Countries', in Martin Fransman and Kenneth King (eds), *Technological Capability in the Third World*, Macmillan

Bell, Martin and Albu, Michael (1999) ‘Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries’, *World Development* 27.9: 1715–34

Bell, Martin and Pavitt, Keith (1995) ‘The Development of Technological Capabilities’, in I.U. Haque (ed.), *Trade, Technology, and International Competitiveness*, Washington DC: World Bank

Bhatnagar, Subhash (2006) ‘India’s Software Industry’, in V. Chandra (ed.), *Technology, Adaptation, and Exports : How Some Developing Countries got it Right*, Washington DC: World Bank

Birkinshaw, J. and Hood, N. (1998) ‘Multinational Subsidiary Evolution: Capability and Charter Change in Foreign-Owned Subsidiary Companies’, *Academy of Management Review* 23.4: 773–95

Bruche, Gert (2009) ‘A New Geography of Innovation – China and India Rising’, *Columbia FDI Perspectives*, Vale Columbia Center on Sustainable International Investment

Brusoni, Stefano (2005) ‘The Limits of Specialization: Problem Solving and Coordination in “Modular Networks”’, *Organization Studies* 26.12: 1885–907

Carneiro-Diaz, A.V.; Salerno, M.S and Zilbovicius, M. (2003) ‘International Division of Labour in Product Development Activities: Towards a Selective De-centralization?’, *Proceedings of the GERPISA 11th International Colloquium*, Paris, 11–13 June

Cassiolato, José Eduardo; Lastres, Helena M.M.; Szapiro, Marina and Vargas, Marco Antonio (2001) ‘Local Systems of Innovation in Brazil, Development and Transnational Corporations: A Preliminary Assessment Based on Empirical Results of a Research Project’, DRUID’s Nelson-Winter Conference, Copenhagen

Chaminade, Christina and Vang, Jan (2008) ‘Globalisation of Knowledge Production and Regional Innovation Policy: Supporting Specialized Hubs in the Bangalore Software Industry’, *Research Policy* 37.10: 1684–96

Chen, Yun-Chung (2008) ‘Why Do Multinational Corporations Locate Their Advanced R&D Centres in Beijing?’, *Journal of Development Studies* 44.5: 622–44

Chesbrough, Henry W. (2006) ‘Open Innovation: A New Paradigm for Understanding Industrial Innovation’, in H.W. Chesbrough, W. Vanhaverbeke and J. West (eds), *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press

—— (2003) *Open Innovation: The New Imperative for Creating and Profiting From Technology*, Boston MA: Harvard Business School Press

Christensen, J.F.; Olesen, M.H. and Kjær, J.S. (2005) ‘The Industrial Dynamics of Open Innovation – Evidence from the Transformation of Consumer Electronics’, *Research Policy* 34.10: 1533–49

Clark, K.B. and Wheelwright, S.C. (1992) ‘Organizing and Leading Heavyweight Development Teams’, *California Management Review* 34.3: 9–28

Commander, S.; Chanda, R.; Kangasniemi, M. and Winters, L.A. (2008) 'The Consequences of Globalisation: India's Software Industry and Cross-Border Labour Mobility', *World Economy* 31.2: 187–211

Consoni, Flavia and Quadros, Ruy (2006) 'From Adaptation to Complete Vehicle Design: A Case Study of Product Development Capabilities in a Carmaker in Brazil', *International Journal of Technology Management* 36.1–3: 91–107

Cooke, Phil (2005) 'Regionally Asymmetric Knowledge Capabilities and Open Innovation: Exploring "Globalisation 2" – A New Model of Industry Organisation', *Research Policy* 34.8: 1128–49

Coombs, Rod; Harvey, Mark and Metcalfe, Stan (2003) 'Analysing Distributed Processes of Provision and Innovation', *Industrial and Corporate Change* 12.6: 1125–55

D'Costa, Anthony P. (2009) 'Extensive Growth and Innovation Challenges in Bangalore, India', in Govidan Parayil and Anthony D'Costa (eds), *The New Asian Innovation Dynamics: China and India in Perspective*, Basingstoke/New York: Palgrave Macmillan

—— (2006) 'ICTs and Decoupled Development: Theories, Trajectories and Transitions', in Govidan Parayil (ed.), *Political Economy and Information Capitalism in India: Digital Divide, Development Divide and Equity*, Basingstoke: Palgrave Macmillan

—— (2002) 'Software Outsourcing and Development Policy Implications: An Indian Perspective', *International Journal of Technology Management* 24.7–8: 705–23

Dias, Ana Valéria Carneiro; Bagno, Raoni Barros; Camargo, Otávio Silva; Pereira, Maria Cecília and Britto, Gustavo (2011) 'Recent Evolutions in R&D Activities in the Brazilian Automotive Industry', paper presented in the 19th GERPISA International Colloquium, 8–9 June

Dossani, Rafiq (2006) 'Globalization and the Offshoring of Services: The Case of India', in S.M. Collins and L. Brainard, *Brookings Trade Forum 2005: Offshoring White-Collar Work*, Washington DC: Brookings Institution Press

Engardio, Pete and Einhorn, Bruce (2005)' Outsourcing Innovation', *Business Week*, 21 March, 82–94

Ernst, Dieter (2009) 'A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks', *Policy Studies*, Honolulu: East-West Center

—— (2008) 'Innovation Offshoring and Outsourcing: What are the Implications for Industrial Policy?', *International Journal of Technological Learning, Innovation and Development* 1.3: 309–29

Ernst, Dieter and Kim, Linsu (2002) 'Global Production Networks, Knowledge Diffusion and Local Capability Formation', *Research Policy* 31.8/9: 1417–29

Evans, P.B. (1992) 'Indian Informatics in the 1980s – The Changing Character of State Involvement', *World Development* 20.1: 1–18

Fifarek, B.J. and Veloso, F.M. (2010) ‘Offshoring and the Global Geography of Innovation’, *Journal of Economic Geography* 10.4: 559–78

Figueiredo, Paulo N. (2006) ‘Special Issue: Firm-Level Learning and Technological Capability Building in Industrialising Economies – Introduction’, *International Journal of Technology Management* 36.1/2/3: 1–13

Gereffi, Gary; Humphrey, John and Sturgeon, Timothy (2005) ‘The Governance of Global Value Chains’, *Review of International Political Economy* 12.1: 78–104

Gerybadze, A. and Reger, G. (1999) ‘Globalization of R&D: Recent Changes in the Management of Innovation in Transnational Corporations’, *Research Policy* 28.2–3: 251–74

Giarratana, Marco; Pagano, Alessandro and Torrisi, Salvatore (2005) ‘The Role of the Multinational Companies’, in A. Arora and A. Gambardella (eds), *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel*, Oxford/New York: Oxford University Press

Giuliani, E.; Pietrobelli, C. and Rabellotti, R. (2005) ‘Upgrading in Global Value Chains: Lessons from Latin American Clusters’, *World Development* 33.4: 549–73

Gregory, Neil; Nollen, Stanley and Tenev, Stoyan (2009) *New Industries from New Places*, Stanford University Press and The World Bank

Harris, Dan; Moore, Mick and Schmitz, Hubert (2009) *Country Classifications for a Changing World*, IDS Working Paper 326, Brighton: IDS

Heeks, Richard (1996) *India’s Software Industry: State Policy, Liberalisation, and Industrial Development*, New Delhi: Sage Publications

Hobday, Michael and Rush, Howard (2007) ‘Upgrading the Technological Capabilities of Foreign Transnational Subsidiaries in Developing Countries: The Case of Electronics in Thailand’, *Research Policy* 36.9: 1335–56

Humphrey, John (2003) ‘Globalisation and Supply Chain Networks: The Auto Industry in Brazil and India’, *Global Networks* 3.2: 121–41

Humphrey, John; Lecler, Yveline and Salerno, Mario (2000) *Global Strategies, Local Realities: The Auto Industry in Emerging Markets*, Basingstoke: Macmillan

Jensen, Peter D. Ørberg (2009) *Offshoring of Advanced and High-Value Technical Services: Antecedents, Process Dynamics and Firm-Level Impacts*, Copenhagen: Department of Intercultural Communication and Management, Copenhagen Business School

Joseph, K.J. and Abraham, Vinoj (2011) ‘Global Innovation Networks or Global Innovation Traps?’, paper presented in workshop on Global Innovation Networks, organised by CEDEPLAR-UFMG, Belo Horizonte, 4–5 May

Krishnan, Rishikesha (2006) ‘Subsidiary Initiative in Indian Software Subsidiaries of MNCs’, *Vikalpa* 31.1: 61–71

Lall, Sanjaya (1992) ‘Technological Capabilities and Industrialization’, *World Development* 20.2: 165–86

Lema, Rasmus (2010) *Adoption of Open Business Models in the West and Innovation in India's Software Industry*, IDS Research Report 62, Brighton: IDS: 1–144

—— (2009a) 'Global Value Chains, Business Organisation and Structural Transformation of Bangalore's Software Cluster in the 1990s and Beyond', in R. Kumar and M. Patibandla (eds), *Institutional Dynamics and the Evolution of the Indian Economy*, Basingstoke: Palgrave Macmillan

—— (2009b) 'Outsourcing and the Rise of Innovative Software Services in Bangalore', Doctoral Thesis, Institute of Development Studies, University of Sussex, Brighton. Published as *Global Redistribution of Innovation Activities: Outsourcing of Software Services and Innovation Capability in Bangalore*, Cologne: Lambert Academic Publishing (2010)

Lema, Rasmus and Hesbjerg, Bjarke (2003) *The Virtual Extension: A Search for Collective Efficiency in the Software Cluster in Bangalore*, Roskilde: International Development Studies, Roskilde University

Lewin, Arie Y.; Massini, Silvia and Peeters, Carine (2008) *Why are Companies Offshoring Innovation? The Emerging Global Race for Talent*, CEB Working Paper 08/009, Brussels: Université Libre de Bruxelles, Solvay Business School, Centre Emile Bernheim

Lynn, Leonard and Salzman, Hal (2007) '"Innovation Shift" to the Emerging Economies: Cases from IT and Heavy Industries', *Sloan Industry Studies*, Boston MA: Massachusetts Institute of Technology (MIT)

Marin, Anabel and Bell, Martin (2010) 'The Local/Global Integration of MNC Subsidiaries and their Technological Behaviour: Argentina in the Late 1990s', *Research Policy* 39.7: 919–31

Maskell, Peter; Pedersen, Torben; Petersen, Bent and Dick-Nielsen, Jens (2007) 'Learning Paths to Offshore Outsourcing: From Cost Reduction to Knowledge Seeking', *Industry and Innovation* 14.3: 239–57

Miles, Ian (2007) 'Research and Development (R&D) Beyond Manufacturing: The Strange Case of Services R&D', *R&D Management* 37.3: 249–68

Mitra, M. Raja (2007) *India's Emergence as a Global R&D Center – An Overview of the Indian R&D Systems and Potential*, Working Paper R2007:012, Ostersund, Sweden: Swedish Institute for Growth Policy Studies

Moavenzadeh, John (2008) 'The Changing Nature of Engineering in the Automotive Industry' in National Academy of Engineering, Committee on the Offshoring of Engineering, *The Offshoring of Engineering: Facts, Unknowns, and Potential Implications*, Washington DC: National Academy of Engineering

Monitor Group (2008) *101 Innovation Breakthroughs*, www.innovation-management.com/downloads/innovation_101_intro.pdf (accessed 10 October 2011)

Morrison, Andrea; Pietrobelli, Carlo and Rabellotti, Roberta (2008) 'Global Value Chains and Technological Capabilities: A Framework to Study Learning and Innovation in Developing Countries', *Oxford Development Studies* 36.1: 39–58

Mudambi, Ram (2008) ‘Location, Control and Innovation in Knowledge-Intensive Industries’, *Journal of Economic Geography* 8.5: 699–725

Myrdal, Gunnar (1968) *Asian Drama: An Inquiry into the Poverty of Nations*, Harmondsworth: Penguin

Mytelka, Lynn K. (2000) ‘Local Systems of Innovation in a Globalized World Economy’, *Industry and Innovation* 7.1: 15–32

Narula, Rajneesh and Dunning, John H. (2010) ‘Multinational Enterprises, Development and Globalization: Some Clarifications and a Research Agenda’, *Oxford Development Studies* 38.3: 263–87

NESTA (2007) *Hidden Innovation – How Innovation Happens in Six ‘Low Innovation’ Sectors*, London: National Endowment for Science, Technology and the Arts

Novak, Sharon and Wernerfelt, Birger (2006) *The Design of Industry*, MIT Working Paper, SSRN eLibrary, Social Science Research Network, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=891870 (accessed 14 January 2012)

Nussbaum, Bruce (2006) ‘“Borderless Thinking” Equals Innovation’, *Business Week*, 2 February, www.businessweek.com/innovate/content/feb2006/id20060202_010265.htm (accessed June 2009)

Oswald, Philipp (2008) *ODIP and the Global Distribution of Innovation Activties in the German Software Industry*, Marburg: Department of Geography, Philipps-Universität

Patibandla, Murali and Petersen, Bent (2002) ‘Role of Transnational Corporations in the Evolution of a High-Tech Industry: The Case of India’s Software Industry’, *World Development* 30.9: 1561–77

Pavitt, Keith (1984) ‘Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory’, *Research Policy* 13.6: 343–73

Piore, M. (2004) ‘The Limits of the Division of Labor in Design and the Prospects for Off-Shore Software Development in Mexico’, *The Software Industry in the Developing World*, New Haven: Yale University

Quadros, Ruy (2009) *Brazilian Innovation in the Global Automotive Value Chain: Implications of the Organisational Decomposition of the Innovation Process*, Research Report, Brighton and Campinas: IDS and DPCT/IG/UNICAMP (Departamento de Política Científica e Tecnológica/ Instituto de Geociências/ Universidade Estadual de Campinas)

—— (2004) ‘Global Quality Standards and Technological Upgrading in the Brazilian Auto-Components Industry’, in Hubert Schmitz (ed.), *Local Enterprises in the Global Economy: Issues of Governance and Upgrading*, Cheltenham: Routledge

Quadros, Ruy and Consoni, Flavia (2009) ‘Innovation Capabilities in the Brazilian Automobile Industry: A Study of Vehicle Assemblers’ Technological Strategies and Policy Recommendations’, *International Journal of Technological Learning, Innovation and Development* 2.1/2: 53–75

Quadros, Ruy and Queiroz, Sergio (2001) 'The Implications of Globalisation for the Distribution of Design Competencies in the Auto Industry in Mercosur', *Actes du Gerpisa* 32, December, Paris: 35–45

Rousseva, Rossitza (2008) 'Identifying Technological Capabilities with Different Degrees of Coherence: The Challenge to Achieve High Technological Sophistication in Latecomer Software Companies (Based on the Bulgarian Case)', *Technological Forecasting and Social Change* 75.7: 1007–31

Salerno, M.; Marx, R. and Zilbovicius, M. (2003) 'Strategies of Product Design, Production and Suppliers Selection in the Auto Industry: Final Findings of a Broad Research in the Major Brazilian Assemblers' Subsidiaries, Headquarters and Suppliers', *Proceedings of the 11th Gerpisa International Colloquium*, Paris

Saliola, F. and Zanfei, A. (2009) 'Multinational Firms, Global Value Chains and the Organization of Knowledge Transfer', *Research Policy* 38.2: 369–81

Saxenian, AnnaLee (2004) 'The Silicon Valley Connection: Transnational Networks and Regional Development in Taiwan, China, and India', in A.P. D'Costa and E. Sridharan (eds), *India in the Global Software Industry: Innovation, Firm Strategies and Development*, Houndmills, Basingstoke, Hampshire/New York: Palgrave Macmillan

Schmitz, Hubert (2007) 'Transitions and Trajectories in the Build up of Innovation Capabilities: Insights from the Global Value Chain Approach', *Asian Journal of Technology Innovation* 15.2: 151–8

Schmitz, Hubert and Strambach, Simone (2009) 'The Organisational Decomposition of Innovation and Global Distribution of Innovative Activities: Insights and Research Agenda', International *Journal of Technological Learning, Innovation and Development* 2.4: 231–49

Simard, Caroline and West, Joel (2006) 'Knowledge Networks and the Geographic Locus of Innovation', in H.W. Chesbrough, W. Vanhaverbeke and J. West (eds), *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press

Strambach, Simone (2009) 'The Organisational Decomposition of Innovation (ODIP) in the German Automotive Industry – Changing Knowledge Dynamics?', mimeo, Workshop Paper for The Changing Knowledge Divide in the Global Economy Project, Brighton: IDS

Strambach, Simone and Dieterich, Iris (2011) *TheTerritorial Shaping of Knowledge Dynamics in Baden-Wurttemberg – Inter-organizational Relations in the Sectoral Knowledge Domain of the Automotive Industry*, Working Papers on Innovation and Space 2011–01, Marburg: Philipps University Marburg, Department of Geography

Strambach, Simone and Klement, Benjamin (2010) *The Organisational Decomposition of Innovation and Territorial Knowledge Dynamics: Insights from the German Software Industry*, Working Papers on Innovation and Space 2010–06, Marburg: Philipps University Marburg, Department of Geography

Sturgeon, Timothy; Van Biesebroeck, Johannes and Gereffi, Gary (2008) 'Value Chains, Networks and Clusters: Reframing the Global Automotive Industry', *Journal of Economic Geography* 8.3: 297–321

Tschang, Ted (2005) ‘The Indian Software Industry: Past Progress and Future Prospects’, *International Journal of Contemporary Sociology* 42.1: 93–106

UNCTAD (2005) *Transnational Corporations and the Internationalization of R&D, World Investment Report*, Geneva: United Nations Conference on Trade and Development

Vang, Jan and Overby, Mikkel (2006) in B.-Å. Lundvall, P. Intarakummnerd and J. Vang (eds), *Transnational Communities, Offshore Outsourcing and Offshore Subsidiaries: The Case of the Indian IT Service Industry*, Cheltenham/Northampton MA: Edward Elgar

Wheelwright, S.C. and Clark, K.B. (1992) ‘Creating Project Plans to Focus Product Development’, *Harvard Business Review* 70.2: 70–82

Wibe, Mona Domaas and Narula, Rajneesh (2002) ‘Interactive Learning and Non-Globalisation: Knowledge Creation by Norwegian Software Firms’, International *Journal of Entrepreneurship and Innovation Management* 2.2/3; 224–45

Yin, R.K. (2002) *Case Study Research, Design and Methods*, Newbury Park: Sage Publications

Zeng, Ming and Williamson, Peter (2007) *Dragons at your Door: How Chinese Cost Innovation is Disrupting Global Competition*, Boston: Harvard Business School Press

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