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Climbing to the top? Reorganising global value chains and building innovation capabilities in Brazil and India

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Abstract

This paper is concerned with global shifts in innovation power. It shows that Brazil and India are accumulating significant innovation capabilities. Most explanations concentrate on factors within these rising powers. This paper concentrates on explanatory factors which have their origin in the old powers (Europe and USA). In order to understand the build-up of innovation capabilities in the new powers it examines their linkages with the old powers, concentrating on the value chains which connect them. It shows how the organisational decomposition of the innovation process emanating from the old powers contributes directly and indirectly to the build-up of innovation capabilities in the new powers. It is clear that a new dynamic has been unleashed but it is not yet clear whether the old powers are contributing to their own demise or renewal. The empirical evidence comes from the Brazilian auto and the Indian software industry and the value chains which link them to the United States and Germany.

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1. Introduction

One of the clearest and best documented transformations in the global economy is the rapid build-up of *production* capabilities in China, India, Brazil and other rising powers. What is less clear is whether these countries are also succeeding in building up significant *innovation* capabilities. Altenburg et al (2008) show that China and India have embarked on the transition from production to innovation but that the break-through is uneven; cutting edge innovation remains rare but adaptive innovation is significant in an increasing number of sectors. Many other studies have been carried out since then confirming that the picture is highly varied between and within sectors. While the variations are enormous, the trend seems clear. Enterprises in the rising powers are no longer just restricted to peripheral innovation activities. Some have accumulated advanced innovation capabilities and are approaching ever more strategic areas. This paper provides evidence for this advance from the Brazilian car industry and the Indian software industry. The main objective of this paper is to show how the re-organisation of global value chains has contributed to this advance.

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 the new powers, these include:

- Big state and private investment in higher education
- Low wages (compared with old powers) for highly educated workers
- The return migration of engineers, scientists, and managers
- The co-location (clustering) of local firms and support institutions
- 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 which 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. Our research shows how this occurs. In a lengthy report, 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 (Lema, Quadros and Schmitz, 2012). This paper brings together the key conceptual and empirical points arising from our comparative research.

A brief clarification of concepts used in this paper will help the reader. 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.[1] Admittedly, there are cases when it is difficult to apply this distinction because of overlaps: knowledge adaptation can be considered both a 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 paper, we are examining sectors and firms in which this is taking place.

When it comes to the global reorganisation 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 paper 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.

The paper is structured as follows: Section 2 goes straight to the heart of the matter: it introduces the conceptual apparatus which gives us an analytical grip on the shifts in the organisation of innovation. Section 3 presents the research questions which this conceptual framework helps us to tackle. Section 4 highlights the strands of literature on which we build and specifies the value added we seek to provide. Section 5 explains how we went out about the empirical work. The core of the paper is Section 6 which presents our main findings. The final Section 7 sets out issues for future research.

2. The organisational decomposition of the innovation process

Our starting point 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

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[1] This distinction draws on the work of Martin Bell and colleagues. The '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).

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.

To get a grip on these changes it is useful to distinguish between:

- Decomposing the innovation process within organisations and between organisations (also referred to as 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 (see Table 1). 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.

Table 1 Types of ODIP

Intra- and Inter-firm / **Connection of Production and Innovation**	**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

Source: Schmitz and Strambach (2009)

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. Our research examines this cross-continental ODIP and goes beyond it by investigating the knock-on effects.

3. The research questions

The concern is 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. The main questions are:

- How has the global value chain been re-organised? 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 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? Are the old powers, having embarked on ODIP, contributing to their own demise?

4. Going beyond the existing literature

The above questions are big and dealt with in separate strands of literature. This section sets out briefly the different strands of work which we seek to bring together. It then shows in which respect we seek to add value to the existing studies.

A. *Bringing together disparate but relevant strands of literature*: 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 work on 'Open Innovation' (Chesbrough 2003, 2006; Christensen *et al* 2005; Cook 2005; 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; Ariffin and Figueiredo 2006; 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; Chen 2008; 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; Morrison *et al* 2008; Schmitz 2007).

B. *Conceptualisation*: While these bodies of work all recognise – in different ways – the 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.

   This is why we use in our research an integrative concept: the organisational decomposition of the innovation process (see section 2). 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.

This is a tall order. The details of how we went about this research are set out in Lema, Quadros and Schmitz (2012). The next section brings together the key methodological points.

5. Methodology

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, Humphrey 2003, Quadros 2004). 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 (Arora *et al* 2008; Athreye 2005; Chaminade and Vang 2008; Commander *et al*. 2008; Rousseva 2008; Saxenian 2004). New clusters specialised in producing software have emerged, in particular in the rising powers.

This cross-sector comparative approach 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 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 related 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.

The data comes from the usual secondary sources and from interviews carried out in India and Brazil. Complementary data was obtained through interviews and correspondence with lead firms in Germany and USA. Whenever possible we sought to bring together the view from above (the lead firm perspective) and the view from below (the supplier perspective). 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 lead firms and suppliers and the latter's ability to rise to the challenges. The information obtained in interviews was complemented with information from company reports, 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.

6. The main findings

The question which drove our research was how ODIP emanating from the old powers influenced the build-up of innovation capabilities in the rising powers. We sought to understand the dynamics at work, recognising that these dynamics were not one way.

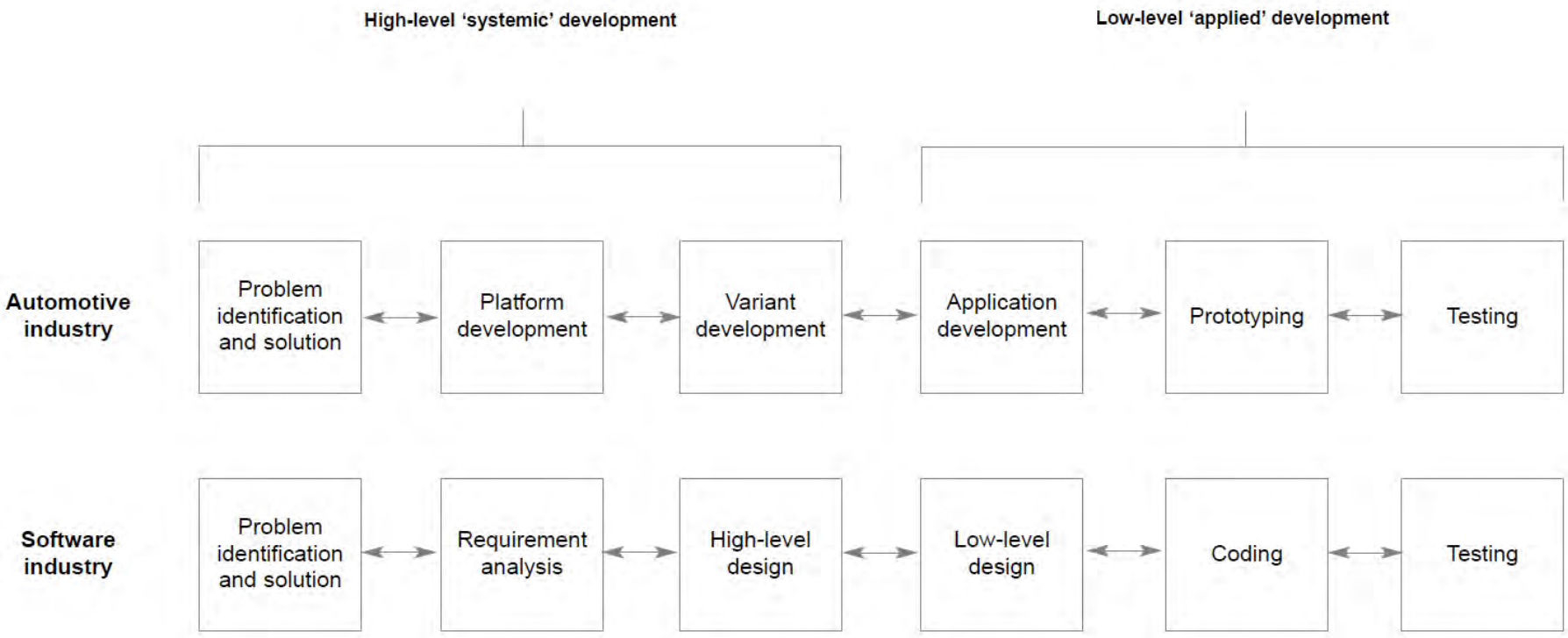
We had no role model for undertaking this project. Essential to its feasibility was breaking the big question into sub-questions which were presented in the earlier section 3. This section 6 gives our answers to these questions. In reflecting on our findings the reader needs to keep two things in mind: first, this is a summary of our findings. In the limited space available we cannot present all the nuances which are included in the research report on which this article is based (Lema, Quadros and Schmitz 2012). Second, we researched the vanguard of the Brazilian auto and India software industries in order to identify the direction of change. Had we sought to give a representative picture we would have had to give more attention to the laggards in the auto and software industries.

6.1 Advances in building innovation capabilities

The dominant argument in the auto and software literature is that the innovation capabilities built up outside the old powers remain at a low level. 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 (Quadros and Consoni 2009). In the Indian software industry, foreign and local suppliers have proven capabilities in high level design (Lema 2009). Yet, much of this Indian innovation remains hidden and is overlooked in R&D-centric studies.

The auto and software industries are very different. Figure 1 helps to make the two comparable for our purposes and bring out the advance made in these two industries.

Figure 1: Product and system development process



Source: Lema et al 2012, 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.

The substance behind Figure 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[3] – but the overall finding in our two industries is clear. The majority of the sampled firms were able to make the shift from low-level 'applied' development to high-level 'systemic' development.

Table 2 Innovation events 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: Lema et al 2012, based on authors' fieldwork: Lema (2009) and Quadros (2009).
Note: Listed alphabetically according to ownership (at time of fieldwork).

Table 2 gives for both sectors ten examples of innovation events reflecting high level 'systemic' capabilities in both the Brazilian automotive and the Indian software industry. For the purposes of illustration, it is worthwhile to elaborate some of these examples.

- *Bosch, Flex power train fuelling system* (auto industry): 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.

- *Sabó, IOSS* (auto industry): Sabó, one of the oldest Brazilian auto parts suppliers, developed 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 which enables

[3] 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.

electronically controlled fuel consumption and emission measurement in the Polo, and later in other vehicles.

- *Infosys, Influx* (software industry): Infosys one of India's largest software developers in India created Influx, a proprietary framework 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 users' 'business requirements' and aids the translation of these into technical specifications.

- *MindTree, Partner CRM* (software industry): MindTree a software start-up established in Bangalore 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.

Formally organised R&D is relatively important for innovation in the auto parts business. Although such R&D is generally less important in the Indian software industry, some suppliers relied on substantial R&D inputs as illustrated in the cases above.

6.2 The role of ODIP

Mono-causal explanations cannot explain the Indian and Brazilian advances in innovation capabilities. We can however conclude from our research that ODIP has made a substantial contribution. 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.

- *Big change in innovation closely connected with production:* ODIP types 2 and 4 dominated (see Table 1): 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 primarily dedicated to product and process design for multinational assemblers such as General Motors and Volkswagen Trucks and Busses and Multinational OECD suppliers such as Bosch, not only for local or regional markets but increasingly also for global markets. When 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 such as Bosch, Nokia, SAP, Siemens or Volvo IT 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 localised in the USA and Europe. The synthesis and integration of different knowledge domains – essential for defining technologies of the future – tend to stay in the USA and Europe. Yet, this has also started to change, although only slowly. For example, the Brazilian subsidiaries of German auto parts producers such as ZF Sachs and Mahle now have introduced R&D units which carry out technological research and experimentation in Brazil. Although less pronounced, software lead firms such as Bosch and SAP also conduct formalised R&D in India, including research for opportunities that

have yet been transformed into products. In the software industry, the strategic core of many service-focused lead firms lies increasingly in non-technical areas and customer-facing functions.

- *Problem solving and problem framing*: We wanted to know whether Indian and Brazilian suppliers could climb into those activities which the lead firms considered strategic. Since 'strategic' is a slippery variable we used Busoni's (2005) distinction between problem framing and problem solving. We found that 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. 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 such as Infosys, MindTree and Wipro acquire capabilities for problem framing (in technical fields) which some US lead firms are beginning to draw upon (Lema 2010, 2012). Such independent suppliers as well as some MNC subsidiaries undertake highly creative work and activities are no longer just predefined by the buyer or the MNC headquarter.

- *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. This effect found in the auto industry is much less pronounced in the software industry where global value chains tend to be 'short'. In the Indian software industry, there are few ODIP connections between MNC subsidiaries and local software service suppliers.

- *Variability between ODIP types and sectors:* The incidence of the various ODIP types found in Brazil and India is summarised in Table 3. The table shows that the various types of ODIP are not equally pronounced and differ between the two sectors. The table includes both the intercontinental ODIP and the subsequent in-country replication of ODIP. In general, the decomposition observed in the auto industry in Brazil involves more actors and these actors tend more often to utilise the full spectrum of ODIP. The decomposition in the software industry involves fewer actors and the innovation activities are typically closely connected to software production (programming activities focused on coding and testing).

Table 3 captures the characteristics and prevalence of the four different types of ODIP observed, but it does not capture the underlying pathways. The ODIP routes taken in the two industries differ, reflecting underlying industry characteristics and different starting points with regard to broader patterns of industrial organisation. In the auto industry, production tends to be 'localised' because of high transportation costs and regulatory arrangements that incentivise local production. The lead firms of the auto value chains are foreign direct investors that were initially driven by the access to the local market. By contrast, software has very low transportation costs and the industry in India is a 'supply platform' for distant end-markets. Global value chains in software were initially dominated by lead firm outsourcing. Major foreign direct investments came later and mimicked the outsourcing patterns. These existing global linkages have been the key channels for initial cross-continental ODIP arrangement. The connection between production and innovation is

strong in both cases and the broader patterns of industrial organisations have influenced the way in which innovation has been decomposed.

Table 3 ODIP Types in the Brazilian Auto and Indian Software Industry

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 suppliers or specialised R&D organisations, collaborating 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.

The differences in the way ODIP unfolds lie not only in the underlying pathways but also in the occurrence of ODIP Type 3. Table 3 shows that this type of ODIP is stronger in the Brazilian auto industry than in the Indian software industry. As indicated in Section 6.1 (Table 2), innovations in the auto industry are mainly focused on material products and associated processes. Brazilian subsidiaries and suppliers provide elements of the many distinct domains of technological knowledge that are involved in car manufacturing. There is often a need to draw on scientific and technical domain knowledge from specialists in research institutes. This occurs in the in-country replication of ODIP. This further decomposition is facilitated by the relative ease of problem specification and formalised abstraction in the auto industry.

By contrast, there is typically little need to use scientific research activities to support the creation of new knowledge in the Indian software industry. This is due to the customer-focused nature of innovations (see section 6.1). Much of the critical domain knowledge is created in interaction with the client. Innovations are often highly specific to the individual

customer. This also means that the cost of codifying the contextualised knowledge involved in innovation is relatively high and it increases with the number of organisations involved. When ODIP Type 3 occurs in the software industry it also occurs as second-round 'replication'. But in contrasts to the auto industry, it tends to be global rather than local. For example such further global decomposition occurs when Indian firms link up to technology development clubs – such as international standard setting networks – as a part of the innovation process.

In summary, our research showed that lead firms have delegated major innovation functions to their subsidiaries and to independent suppliers in Brazil and India although there are significant variations in how this occurred and unfolded. In the automotive case, there is typically a sequential pattern of intra-firm innovation offshoring followed by further outsourcing to local suppliers which are the indirectly affected by the initial ODIP decision. In India, local suppliers typically deal directly with buyers located in Europe or the USA and are directly affected by their ODIP decisions. Although the routes are different, local suppliers are drawn in to the decomposed innovation process and become deeply involved in systemic development activities.

6.3 Directions of causality and contingent factors

The initial aim of this research was to understand 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. However, the evidence of this unearthed during the research raised new questions about contingencies and reverse causalities.

- *Contingencies:* The most innovative firms in both industries had substantial histories of technological learning and they invested continuously in knowledge creation. 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 and mediating variables 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. 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.

A new dynamic is unfolding but it is 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 process in the course of which major geographical shifts of innovation capabilities take place.

7. Future Research

Three kinds of further research are needed: first, deepening the research of the issues we have investigated for the same sectors; second, extending the research to other sectors and countries; and third posing new questions. This final section presents brief reflections on all three.

The research report, on which this article is based, draws attention to variations in robustness of the evidence. It indicates where we have substantial evidence and where the evidence is more tentative. For example, our data from suppliers is more robust than that obtained from lead firms. We have more evidence on the causality from ODIP in the old powers to the build-up of innovation capabilities in the new powers than on the reverse causality. Hence there is a case for conducting new research on those connections where uncertainties are greatest – and for updating the findings in the process.

Researching ODIP and its effects in *other sectors* is essential for the following reasons. While we contend that this research has captured the direction of change in the re-organisation of global value chains and geographical shifts in innovation power, we recognise that sectoral variations will remain. Giuliani, Pietrobelli and Rabellotti (2005) have stressed – in a previous round of research on upgrading in global value chains – that sectoral specificities matter. There is no reason to think that this has changed. Studying the questions we addressed in this article for other sectors is important. It would be particularly interesting to study the green industries such as renewable energy industries. There is an expectation in some business and government circles that these new industries provide an opportunity for the old powers to re-establish their prominence in innovation and revitalise their economies through green jobs. At the same time there are indications that European lead firms in the green industries are decomposing their innovation process and that Asian firms are investing in their production and innovation capabilities (Pedersen 2009; Lema et al 2011; Lema and Lema 2012). Using the ODIP approach provides a promising way of capturing the change in these industries of the future.

For a country like Brazil, studying the changing value chains in mining would be particularly interesting, given the increasing importance of this old sector in international trade. The main source of innovation has traditionally been the engineering industry in the old powers. Yet, this is changing with producers/operators along the value chain participating actively in the innovation process and old engineering firms entering new arrangements with these new innovators. ODIP seems critical to the build-up of innovation capabilities in new places.

Future research will also have to tackle new questions – relating to both old and new industries. As indicated in the title of our paper, our central objective was to understand the changing organisation of global value chains and the opportunities for building innovation capabilities in the rising powers. In this respect two new factors deserve attention: rising power lead firms and lead markets. For example, Brazilian and Indian suppliers in the global auto and software chains are themselves turning into global firms, establishing (or acquiring) operations abroad and entering new markets. It seems that going global is an important step for these formerly subordinated suppliers to become lead firms in their value chains. This is sometimes but not always connected to the emergence of new lead markets in the rising powers. Markets in the old powers are stagnating. There is some movement but little net growth. In contrast, markets in the new powers are expanding rapidly, not just replicating the demand profile of the old powers but developing specificities which reflect their own conditions. We know that lead markets have an impact on where innovation happens and

what it is focussed on. This might extend to a shift in location of the most strategic innovation power which has traditionally resided in Europe, North American or Japan.

In conclusion, over the last 10 years we have seen major changes in the global distribution of innovation activities. Our research suggests that ODIP has made a substantial contribution to this shift and sought to grasp the processes which make it happen. We can only speculate on what the global innovation map will look like in 10 years from now. So as to give this speculation some direction, one can distinguish two scenarios:

- The first scenario is co-evolution of the old innovating regions in Europe and 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 (for the old powers) but the result is win-win.

- The second scenario also stresses intense interaction but the result is one side losing and the other winning. 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 would be digging their own grave.

Only time can tell which of these scenarios captures real developments. Of course it could be that neither prevails and that the outcome will be highly differentiated, varying a great deal between sectors. This does not mean that everything is uncertain. It is clear from this paper 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 in the new powers.

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