MULTINATIONAL STRATEGIES, LOCAL HUMAN CAPITAL, AND GLOBAL INNOVATION NETWORKS IN THE AUTOMOTIVE INDUSTRY*

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Introduction

This paper focuses on the relationship between strategies of Northern and Southern firms, mostly multinational enterprises (MNEs), and human capital in Southern host countries in the automotive supply industry, and the implications of this relationship both for the management of technological change and for the constitution of global innovation networks (GINs). We define GINs as global networks in which some knowledge-intensive activities are based in developing countries. They differ qualitatively from the better known global production networks (GPNs) where Northern MNEs traditionally control the key technological assets, while outsourcing the supply of parts and components or assembly to contract manufacturers. This version of the paper is based on case studies from Germany and South Africa; we aim to add case material from Italy, India, and Brazil in the subsequent version.

GINs are a result of the emerging geography of knowledge-intensive activities in the global economy. On the one hand, the increasing complexity of knowledge required for global competitiveness, shorter innovation and product cycles, and the associated cost pressures have led MNEs to offshore and outsource R&D (Archibugi and Iammarino, 2002; Wooldridge, 2010). On the other hand, the spread of technological capabilities in a number of advanced developing economies, including lower middle-income countries such as China and India, have opened opportunities for design, applied development, and even basic research (UNCTAD, 2005). What is new is not the offshoring or outsourcing of R&D per se (OECD, 2007), but the gradual involvement of firms and other actors such as universities and research labs from a few developing countries in what until a decade or so ago played itself out exclusively among the advanced Triad economies plus a few latecomers from East Asia, notably Korea and Taiwan.

The evidence concerning GINs is not comprehensive. To date it is primarily based on indications of CEOs or R&D managers of important Northern MNEs who participated in surveys (Dilk, Gleich, and Wald, 2008; UNCTAD, 2005) or on descriptions of individual examples of such GINs, often in the business press (Wooldridge 2010). A 2010 survey of 1215 companies in six European countries and in Brazil, China, India, and South Africa in three industries (agro-food, automotive, and ICT) revealed that 25 per cent offshored either production or R&D, and that, next to market access, the availability of specialized competences and qualified human capital at lower cost than in the home region, as well as access to knowledge infrastructure and services in the host region were the most important location-specific advantages. Between five and six per cent additionally reported that subsidiaries in developing countries were responsible for strategic management, product development, and technology and process development (see Appendix for more information in the survey).

While the existence of GINs is not in doubt, their evolution is less clear. We do not know much about the micro determinants of the dynamics underlying the transformation of GPNs into GINs. Dutrénit (2004) pointed out that the literature on technological upgrading in developing countries had only ever asked how firms graduated from simpler to more sophisticated capabilities, without looking at subsequent trajectories that would bring them closer to the global technological frontier (see also Lorentzen, 2009). To some extent, this simply reflected an empirical reality, namely that the majority of developing country firms did not “innovate” in the sense of pushing the frontier.
Yet apart from the fact that there were important Southern firms that did not fit the idea of “innovation” only as “adaptation” (Hobday, Rush, and Bessant, 2004; Kim, 1997) – Samsung’s overtaking of Sony is but one example (Chang 2008) – the small size of this phenomenon does not justify the neglect of the conceptual and theoretical treatment afforded to the evolving technological trajectories of developing country firms toward new-to-the-world activities. Apart from the fact that it was always unlikely to remain small, it is incumbent upon researchers to recognize the limitations of the existing literature and think more systematically about how developing country firms mastered the hardly trivial process of moving from excellence in execution to more creative activities in which knowledge played an increasing role.

The present paper is an attempt to contribute to a better understanding of the micro determinants of GINs. Lall (2001) analysed the relationship between education and skills systems, and technological trajectories in East Asia. He showed how education and skill strategies must anticipate technical change in order for host economies not only to become and remain attractive locations for multinational investment, but also to exploit the associated knowledge transfer and spillover in support of economy-wide upgrading. Yet he did not look at R&D capabilities.

This paper addresses these issues on the basis of a set of matched case studies from a European car producing economy (Germany), whose assemblers and suppliers have investments in important advanced developing countries (India and South Africa). It also includes Southern firms that invested in Europe to access knowledge from more advanced suppliers. The analysis focuses on specific instances of technical change, how they were supported by human capital upgrading, and what difference this made (or not) for the control of technological progress within each value chain.

The next section briefly reviews relevant literature on the relationship between human capital and MNE strategies. Then we present an overview of pertinent developments in the global automotive industry, followed by background on South Africa’s education and skills system, as well as on FDI in the country. Afterwards we present data and methodology, and finally analyse the cases before concluding.

**MNEs and human capital**

MNEs embody certain capabilities while at the same time looking for new ones in a few advanced developing countries. In the South, education and training systems are an essential element of high absorptive capacities which in turn are a prerequisite for GINs. Hence there is a two-way relationship between FDI and local human capital. Two-way refers to the attraction educational achievements hold for inward direct investment (Noorbaksh, Paloni and Youssef 2001, Te Velde 2005, see also Dunning 1993) and to the influence MNEs exert over education and training systems post-entry both directly (Borensztein et al 1988, Lall and Narula 2004, Lorentzen 2008, Spar 1996, Tan and Batra 1995) and because they increase competition (Chuang 2000, Grossman and Helpman 1991, Moran 1998), while accelerating skill-biased technological change (Berman et al 1988, Te Velde and Xenogiani 2007).

Lall analysed dynamic upgrading (2001, esp. Chapters 5, 7) by linking the capability approach with an analysis of human capital (see also Green et al 1999). Important elements of firm-
level capabilities and, hence, learning include the following. First, since technologies make
different demands on learning requirements, the learning process is technology specific.
What works in an electronics plant where an essentially codified new technology may be
embodied in a new piece of capital equipment, is not necessarily relevant for an automotive
supplier facility where an emerging technology may be a lot more tacit (Jung and Lee 2010).
This also means that when tacit knowledge is important, the role of geographic proximity
rises. The breadth of skills and knowledge required to master new technologies also differs,
as does the time to take them on.

Second, different technologies depend to differing degrees on external sources of
information. In the extreme case one might think of an almost self-contained cluster as
opposed to a global technology network to which different firms and research institutes or
migrating knowledge workers contribute. Third, relevant human capital inside the firm
includes everybody from the shop floor to senior management. The design of a new product
may primarily be in the hands of a few R&D engineers. Yet whether their research leads to a
commercially successful innovation also depends on the efficiency and quality with which
workers turn prototypes into products.

Fourth, technological trajectories cannot be successful by relying exclusively on the mastery
of operational know-how without deepening this to understand know-why, especially in the
context of GINs as opposed to GPNs, where the exclusive pursuit of operational know-how
may be a feasible strategy. Fifth, technological learning takes place in an environment
characterized by externalities and linkages which in turn depend on institutional
characteristics. Education and training institutions are among those that matter prominently

In looking at the specific linkages between MNEs and local human capital, it is pertinent to
distinguish between internalized as opposed to externalized transfers of technology. When a
MNC chooses to keep (proprietary) technology to itself, the transfer of know-why (but not
typically of know-how) may suffer, unless local R&D capabilities are already high (which in
developing countries they of course often are not). Either way, local firms must develop the
skills and the knowledge to master the tacit elements of whatever it is that is being
transferred.

Much as early and later stages of catch-up require different kinds of skills and competences,
there are presumably differences in terms of the level of sophistication at which latecomer
countries, regions, firms or other actors get involved in GINs. These differences may play
out within the very same country – for example, whereas a university may be involved in
basic research that feeds into the design part of a GIN, a firm may contribute productive
activities that are mere assembly. So although the terminology of national technological
capabilities is a useful way of thinking about the technological trajectories of countries, it of
course does not mean that entire countries get slotted into GINs at specific levels of (high or
low) technological sophistication, but rather at a range of activities (see also Hobday et al
2005). Undoubtedly however, the emergence of GINs implies that education and training
systems can on average no longer provide a merely literate and numerate workforce, as they
may have done at the very beginning of technological capability building.
Trends in the global automotive manufacturing industry
Global growth and the market shift from West to East (and North to South)

Global vehicle production more than doubled between 1975 and 2007, coinciding with rapid globalization and the restructuring of global automotive value chains (GVC). The relative weight of developing countries, especially India and China, in vehicle output has increased, whereas production and sales have shrunk in Western Europe and North America (Sturgeon et al, 2009; see Table 1). Between 2007 and 2009, the share of developing country original equipment manufacturers (OEMs) in global production increased from 1.9 per cent to 7.5 per cent, largely due to growth in China. During this period the Asia-Pacific region was the only one to increase its proportion of both global sales (by 2%) and global production (by 7%) (Automotive World Automotive Passenger Car OEM Quarterly Data Book, 2009).

Table 1 – World car sales and production by sub-regions 2001-07 (million units)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe, West</td>
<td>14.93</td>
<td>15.00</td>
<td>14.65</td>
<td>14.75</td>
</tr>
<tr>
<td>Europe, East</td>
<td>2.13</td>
<td>2.45</td>
<td>2.83</td>
<td>3.13</td>
</tr>
<tr>
<td>North America #)</td>
<td>19.03</td>
<td>13.70</td>
<td>18.51</td>
<td>14.32</td>
</tr>
<tr>
<td>Latin America #)</td>
<td>2.80</td>
<td>3.71</td>
<td>3.07</td>
<td>3.79</td>
</tr>
<tr>
<td>Asia-JO</td>
<td>4.90</td>
<td>8.40</td>
<td>5.46</td>
<td>9.06</td>
</tr>
<tr>
<td>Asia-DK</td>
<td>3.58</td>
<td>4.67</td>
<td>6.40</td>
<td>7.81</td>
</tr>
<tr>
<td>Middle East</td>
<td>1.00</td>
<td>-</td>
<td>1.85</td>
<td>-</td>
</tr>
<tr>
<td>Africa</td>
<td>0.66</td>
<td>0.23</td>
<td>0.77</td>
<td>0.24</td>
</tr>
<tr>
<td>Total</td>
<td>49.03</td>
<td>48.16</td>
<td>53.54</td>
<td>53.10</td>
</tr>
</tbody>
</table>

Notes: Western Europe is the old EU-15 plus other Western countries. Eastern Europe is the new EU-12 + CIS and Turkey. North America is Canada and USA; Latin America is South America and Mexico. Asia-JO is Japan and Oceania (Australia and New Zealand). Asia-DK is Asia minus Japan and Oceania, i.e. Developing Asia (incl. Iran) and South Korea. #) Includes light trucks in both sales and production figures.

The onset of the world financial crisis in 2008 exacerbated this trend. Prior to the crisis, analyses of the structure of the automotive market tended to underline the importance of regional markets, since OEMs historically produced and sold most of their cars in their home regions in Europe, Japan, and North America (Sturgeon et al, 2009). Both political
(the iconic stature and the influence of the industry) and economic (such as just-in-time (JIT) requirements and logistical problems associated with heavy components) factors militated in favour of regionalisation. The market shift eastwards was characterized as gradual and unlikely to change global dynamics dramatically. However, with the financial crisis it became clear that the shift had accelerated and that it was likely to cause far-reaching changes in global value chains, and consequent changes in the geography of production and innovation (Wad, 2010).

Global value chain re-structuring

Value chains in the automotive industry are producer driven (Gereffi, 2005), which means that lead firms, namely the OEMs and a few large global suppliers, all of which are still located in developed countries, account for the bulk of innovation activity, the production of most engines and transmissions, and almost all vehicle assembly functions. These firms have strong co-ordination capabilities and huge buying power, and the top-ten automotive groups dominate the global market (Wad, 2010). The largest first-tier suppliers have become system integrators; they take on an increasingly larger role in R&D, innovation, production, and the allocation of investment. This has increased their bargaining power within the supply chain (Becker, 2006, Birchall et al, 2001, Chanaron and Rennard, 2007).

In the re-structuring of global value chains in the 1990s and 2000s, MNEs took majority control of many joint-venture assembly operations. Suppliers from the OEMs’ home regions set up operations in proximity of foreign locations of the assemblers, a process referred to as follow-source. In addition, domestic suppliers were largely relegated to the second or third tier, or were taken over (Barnes and Kaplinsky, 2000, Barnes and Morris, 2008, Humphrey et al, 1998; Humphrey and Memedovic, 2003; Rutherford and Holmes, 2008.).

The financial crisis turned the heat on OEMs and accelerated supplier consolidation. The number of first tier suppliers was predicted to fall globally from 8,000 in 2002 to around 2,000 by 2010, driven by a weak financial position of the industry, acrimonious relationships between OEMs and suppliers, as well as low capacity utilisation (Barnes and Morris, 2008, Osterman and Neal, 2009, Maxton and Womald, 2004, Ch. 7). The growth of large global suppliers – for example Bosch, whose turnover rivals that of smaller assemblers – will possibly lead to the eventual emergence of six to ten globally dominant first tier systems integrators. FDI into developing countries added to global overcapacity, further fuelling cost pressures (Sturgeon and Van Biesebroeck, 2010).

Innovation and upgrading

The concentration of power within a few lead firms has implications for the structure of innovation. Innovation takes place at large firms – OEMs like Ford and Daimler are consistently among the top spenders on R&D worldwide (Dehoff, K. and Jaruzelski, B. 2009) and moves in a top-down fashion. Assemblers create unique standards and specifications, necessitated by the high level of inter-relationships in the performance characteristics of components that differ for every model. Together with the absence of open industry-wide standards, this undermines value chain modularity and makes supplier investments relationship-specific, further reducing the scope for innovation among smaller firms. The close collaboration between suppliers and assemblers leads to agglomerations of
firms near the headquarters of assemblers and large tier 1 suppliers. The industry effect is a
limit of economies of scale in production and of scope in design.

However, vehicle and component R&D has achieved greater global integration than
production, as firms have sought to leverage their design functions across multiple products
and end markets, a process referred to as follow-design, while eventually adapting each
model to its specific market conditions (Humphrey and Memedovic, 2003, Sturgeon et al,
2009). This creates high barriers to entry and limits prospects for upgrading by smaller firms
and firms in developing countries.

At the same time, contrasting dynamics are influencing the conduct of innovation in the
industry. Very large and growing markets such as Brazil, China, and India make it profitable
for assemblers to adapt existing or even to produce specific models (Brandt and Van
Biesebroeck, 2008). OEMs thus establish regional headquarters as well as regional design and
innovation centres. In turn, this creates pressure for lead suppliers to follow suit and to
source inputs from local second tier suppliers which might end up supplying assemblers
directly. Similarly, OEMs use advanced developing countries, whose markets do not justify
specific models but are large enough to warrant local assembly, as regional production hubs.
In countries such as South Africa, Thailand and Turkey, this opens opportunities for local
suppliers, including for export. By contrast, developing countries that are close to and can
supply on a JIT basis to a regional trade block, tend to specialise in labour-intensive
components. If capability upgrading occurs, opportunities may arise for the production of
capital intensive parts and even assembly (Carillo,????; Lorentzen, Møllgaard, and Rojec,
2003). Finally, lead local firms can work with highly specialised engineering and design
houses and source from the world’s top system integrators to achieve competitiveness first
locally and later perhaps globally. For example, the Chinese OEM Chery, working with
suppliers such as Pininfarina and Bosch, started production in 2001, only to become China’s
largest vehicle exporter by 2006 (Sturgeon and van Biesebroeck 2010).

In sum, technological trajectories depend on the interplay between both Northern and
Southern MNE strategies and local absorptive capacities, mediated by geography (cf.
Sturgeon and Van Biesebroeck 2010). The most straightforward channel is technology
transfer from MNEs to their subsidiaries (e.g. Ivarsson and Alstram 2005). Learning can, but
need not, take place in JVs (e.g. Nam, 2010; Sadoi, 2008). Upgrading can also take place
when a Northern supplier transfers technology to a Southern assembly plant or when a
Southern assembler acquires the competences of a Northern firm, a strategy followed by
Chinese OEMs Sichuan Tengzhong Heavy Industrial Machinery Company, Geely, and
Beijing Automotive Company (BAIC), with their purchases of Hummer from General
Motors, Volvo from Ford, and rights to Saab styling and technology, respectively, or Indian
OEM Tata’s acquisition of Jaguar and Land Rover. Of course none of these strategies is
guaranteed success in terms of transfer of especially the tacit knowledge that would allow the
Southern firm to bridge existing technology gaps, certainly not in the short term.

Global innovation networks?

By comparison to other industries, notably electronics, it is evident that GINs do not (yet)
characterise the automotive sector. The most important OEMs and suppliers continue to be
located in a few regions in a few developed countries. They control a very hierarchical value
chain, based on follow-design and follow-source, and centralise (most) R&D. Due to the
nature of automotive technology, investments are often asset-specific and closely tie suppliers to assemblers and system integrators. Finally, the industry is already highly concentrated and this is likely to increase further. The general consensus in the literature is that the combined effect of these characteristics is to curtail opportunities for new-to-world innovation for Southern firms.

Table 2 – Characteristics of the automotive industry

<table>
<thead>
<tr>
<th>Feature</th>
<th>Does not favour GINs</th>
<th>Favours GINs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value chain hierarchy</td>
<td>A few OEMs and system integrators in the North control all activity. Unique standards and specifications require asset-specific investments. OEMs insist on follow-design.</td>
<td></td>
</tr>
<tr>
<td>Value chain knowledge architecture</td>
<td>Division of labour in R&amp;D between OEMs and lead suppliers leads to agglomerations in the North and to follow-source.</td>
<td>Follow-source in large emerging markets involves local second-tier suppliers that can move up the hierarchy.</td>
</tr>
<tr>
<td>Consolidation</td>
<td>Raises barriers to entry for small and developing-country firms.</td>
<td></td>
</tr>
<tr>
<td>Cost pressures</td>
<td></td>
<td>Opens opportunities for high-level capabilities in traditionally high-cost activities from lower-cost sources in developing countries.</td>
</tr>
<tr>
<td>Market size and growth</td>
<td></td>
<td>Production and sales in Brazil, China, and India are catching up on automotive heartlands. Adaptation of existing and design of new dedicated models create demand for R&amp;D.</td>
</tr>
</tbody>
</table>

However, it is also evident that the industry, especially in the context of the global financial crisis, is changing. Markets in Asia are slowly outgrowing the automotive heartlands in the Triad economies. The design of specific new models as well as adaptations of existing models relies in part on local design and innovation centres that create demand for R&D. At the same time, two decades of production of cars for global markets by developing country producers have raised their technological capabilities. Some of these firms are sufficiently confident to acquire Northern assets to advance their upgrading yet further towards the frontier. In addition, cost pressures on the industry make it irrational to neglect stronger absorptive capacities in developing countries, including in R&D. Taken together, this does not mean that the emergence of GINs is a foregone conclusion. But it does mean that the literature is wrong to neglect or dismiss powerful economic arguments in favour of R&D offshoring and outsourcing and advance an interpretation of automotive industry dynamics based more on the past than on a consideration of possible future developments, as well as incipient instances of knowledge intensive activities in the South that point to a gradually evolving, different landscape.
In sum, trends in the automotive industry do not all point in the same direction (see Table 2). Features that have been characterizing the industry since the early 1990s – hierarchy, knowledge architecture, and consolidation – do not on balance favour the evolution of GINs. On the other hand, cost pressures which have been around for decades but which the global financial crisis has exacerbated, bringing a few OEMs to the brink of bankruptcy, and the eastward shift of markets both for production and sales open up opportunities for firms in countries like Brazil, China, and India. They can combine their advanced capabilities with market-seeking investments by OEMs to work on adaptation as well as dedicated new vehicle models. OEMs and lead suppliers, in turn, can adjust to cost pressures by exploiting high-level capabilities in R&D that firms and research institutes in these countries offer at more competitive prices.

**Automotive foreign direct investment and absorptive capacity in South Africa**

Until the early 1990s, the South African automotive industry, which included most large OEMs, was largely cut off from international competition, investment, and value chain relationships. It primarily supplied the domestic market and was not internationally competitive. All except the German-owned MNCs had largely divested from the country, leaving their brands in local ownership. Following political changes in the country, the OEMs returned to South Africa and reacquired their assets. They were attracted by the Motor Industry Development Plan (MIDP), an industrial policy aimed at attracting inward direct investment and featuring an import-export complementation scheme, by which component and vehicle exporters could earn credits to offset import duties (Barnes, 2000).

Just as in other developing and transition economies, component producers followed suit. Between 1997 and 2003 sourcing from domestic multinational subsidiaries increased from 26 per cent to 37.5 per cent of the supply base, while the use of local firms with local technologies declined from 25.8 per cent to only 10 per cent (Lorentzen and Barnes, 2004). Between 1997 and 2008, investments by assemblers amounted to ZAR31.2bn of which eight per cent was devoted to R&D and engineering (Gastrow and Gordon, 2010). This paled in comparison to investments undertaken in Brazil, Mexico, China, Thailand, and Central Europe (Black, 2009). However, BMW, Daimler, and VW positioned their South African operations as a key element in their globalization strategies of the 3-series, the C-Class, and the Golf GTI, respectively, seeking not only greater production efficiencies but export capabilities, and invested accordingly. Between 1995 and 2008 South Africa’s production increased from 278,000 to 563,000 units, largely driven by exports, which increased from 16,000 unit in 1995 to 284,000 in 2008, or from four per cent to 51 per cent of total production (Gastrow and Gordon, 2010).

South Africa suffers from severe skill constraints. Although the country spends massively on education and achieves comparatively high enrolment rates, in many indicators the education system ranks at the bottom of international league tables (see Table 3), especially in math and science education and the availability of scientists and engineers. Brain drain is also a problem. At the same time, the country has relatively good public research organizations, business schools, and university-industry linkages.

But these are average assessments. More important is how skills constraints affect automotive firms, how firms address them, and with what effect. Even while the industry increased investment, production, and exports from the second half of the 1990s, the
availability of mid- and high-level skills was largely sufficient (Black, 2009). OEMs played a major role in upgrading unskilled and semi-skilled workers as well (e.g. Lorentzen, 2007).

The result of investment in plant and human capital upgrading was that the local industry significantly improved its performance to reach world-class levels. In terms of cost control, quality, flexibility, reliability, human resources, and product testing, South African plants closed the gap to their international competitors which in the early 1990s had been rather large. In quality, local plants ranked better than the international average (Barnes and Morris, 2008), and the performance of local subsidiaries such as the BMW plant in Roslyn occasionally exceed their parent operation in Germany (Goldstein, 2003, quoting JD Powers Gold Quality Awards, 2002). In sum, the technological and organizational performance of the industry as a whole and the capabilities of its human capital improved over the last decade and a half.
Table 3 – Comparative human resources indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>SA</th>
<th>Brazil</th>
<th>India</th>
<th>China</th>
<th>Germany</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector education expenditure as % of GDP 1999</td>
<td>6.03</td>
<td>3.88</td>
<td>4.47</td>
<td>1.91</td>
<td>n/a</td>
<td>World Bank 2010; UNESCO 2010a</td>
</tr>
<tr>
<td>Public sector education expenditure as % of GDP 2007</td>
<td>5.34</td>
<td>5.21</td>
<td>3.18*</td>
<td>3.22**</td>
<td>n/a</td>
<td>World Bank 2010; UNESCO 2010a</td>
</tr>
<tr>
<td>Public sector education expenditure per capita (2007) USD</td>
<td>316.86</td>
<td>374.27</td>
<td>27.21*</td>
<td>231.35**</td>
<td>n/a</td>
<td>World Bank 2010; UNESCO 2010a</td>
</tr>
<tr>
<td>Gross tertiary enrolment as a % of the total 18-24 age cohort 2000</td>
<td>12.9#</td>
<td>16</td>
<td>10</td>
<td>7.8</td>
<td>n/a</td>
<td>World Bank 2010; # Department of Education, 2007</td>
</tr>
<tr>
<td>Gross tertiary enrolment as a % of the total 18-24 age cohort 2007</td>
<td>16.2#</td>
<td>30.01</td>
<td>13</td>
<td>22.05</td>
<td>n/a</td>
<td>World Bank 2010; # Department of Education, 2007</td>
</tr>
<tr>
<td>Brain drain ranking**A19</td>
<td>62</td>
<td>39</td>
<td>34</td>
<td>37</td>
<td>31</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Quality of educational system****</td>
<td>130</td>
<td>103</td>
<td>39</td>
<td>53</td>
<td>18</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Quality of math and science education****</td>
<td>137</td>
<td>126</td>
<td>38</td>
<td>33</td>
<td>39</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Availability of scientists and engineers****</td>
<td>116</td>
<td>68</td>
<td>15</td>
<td>35</td>
<td>27</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Quality of management schools****</td>
<td>21</td>
<td>73</td>
<td>23</td>
<td>63</td>
<td>31</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Quality of scientific research institutions****</td>
<td>29</td>
<td>42</td>
<td>30</td>
<td>17</td>
<td>6</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
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<tr>
<td>Internet access in schools****</td>
<td>100</td>
<td>72</td>
<td>70</td>
<td>22</td>
<td>39</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Extent of staff training****</td>
<td>26</td>
<td>53</td>
<td>59</td>
<td>57</td>
<td>8</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>University-industry linkages****</td>
<td>24</td>
<td>34</td>
<td>58</td>
<td>25</td>
<td>9</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Local availability of R&amp;D services****</td>
<td>49</td>
<td>36</td>
<td>51</td>
<td>50</td>
<td>2</td>
<td>WEF Global Competitiveness Report 2010-2011</td>
</tr>
<tr>
<td>Top 200 ranked universities</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>10</td>
<td>QS World University Rankings 2010</td>
</tr>
<tr>
<td>% of tertiary graduates in science fields 2008</td>
<td>4</td>
<td>6.77</td>
<td>n/a</td>
<td>n/a</td>
<td>13</td>
<td>UNESCO 2010a</td>
</tr>
<tr>
<td>% of labour force with a tertiary education</td>
<td>13</td>
<td>8.6#</td>
<td>n/a</td>
<td>7##</td>
<td>24</td>
<td>UNESCO 2010a, # = 2006, ##<a href="http://english.peopledaily.com.cn/">http://english.peopledaily.com.cn/</a></td>
</tr>
<tr>
<td>Thompson Reuters' Science Citation Index publicationS % change 2002-2008</td>
<td>48.3</td>
<td>110.6</td>
<td>91.7</td>
<td>174.7</td>
<td>24.1#</td>
<td>UNESCO 2010b, #EU total</td>
</tr>
<tr>
<td>Patent output 2007 per million of population</td>
<td>1.86</td>
<td>0.65</td>
<td>0.64</td>
<td>118.02</td>
<td>9713</td>
<td>UNESCO Science Report 2010</td>
</tr>
</tbody>
</table>

Notes: * = 2006, ** Source: People's Daily 2009, *** A lower ranking indicates greater brain drain, **** WEF rankings out of 139 countries
Methodology and data

In order to identify the joint effect of firm strategies and local absorptive capacities on the nature and quality of technical change, we selected German first-tier supplier MNEs with investments in one or more of South Africa, Brazil, and India. We did a similar exercise with Italian firms, including an OEM, which had investments in one or more of Brazil and South Africa. Research teams in each of these countries contacted their respective firms and arranged interviews with managers in charge of R&D, technology, or innovation as well as of human capital. This resulted in three lists of case studies. The first list contained matched firms where the teams interviewed both headquarters and subsidiary. The second list contained “like-with-like” matches where we interviewed different suppliers competing on the basis of similar product portfolios. The third list contained firms that were not matched but that nonetheless provided valuable illustrations of the research question. Firms on the first list allowed for triangulation and were the most interesting in that they occasionally revealed different viewpoints of managers of the same firm, depending on whether they were based in the South or the North. We compiled profiles for each firm, based largely on trade magazines and other specialist literature. The actual interview was semi-structured and focused on upgrading and location strategies, human capital, and the management of technological change. Interviews took place in the second half of 2010 and lasted up to two hours. Researchers produced a synthesis of the conversation which they submitted to the interviewees for the vetting of accuracy. The firms were assured confidentiality.

This version of the paper features five firms drawn from the first and the third lists (see Table 4).

Table 4 – Case studies description

<table>
<thead>
<tr>
<th>Firm</th>
<th>Turnover 2009</th>
<th>Locations</th>
<th>Product range</th>
<th>Interviews conducted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivetraincomp</td>
<td>€5-10 bn</td>
<td>Global: 180 locations in 50 countries</td>
<td>clutches and bearings</td>
<td>South Africa</td>
</tr>
<tr>
<td>exhaustcomp</td>
<td>€1-5 bn</td>
<td>Global: locations in more than 20 countries</td>
<td>exhaust systems, heating systems</td>
<td>Germany, South Africa, India (planned)</td>
</tr>
<tr>
<td>Tempcomp (list 1)</td>
<td>€1-5 bn</td>
<td>Global: 22 production locations, 11 development centres, and two fully equipped R&amp;D centres.</td>
<td>heating and cooling systems</td>
<td>Germany, South Africa (planned), India (planned)</td>
</tr>
<tr>
<td>Elecsys1 (list 3)</td>
<td>€0-1 bn</td>
<td>HQ and manufacturing in South Africa, sales and R&amp;D centres in the UK and US</td>
<td>electronics</td>
<td>South Africa</td>
</tr>
<tr>
<td>Elecsys2 (list 3)</td>
<td>€0-1 bn</td>
<td>HQ in South Africa, subsidiaries in the UK and Australia</td>
<td>electronics</td>
<td>South Africa</td>
</tr>
</tbody>
</table>

Note: Turnover is given in ranges to protect anonymity.
The human capital dimension of the interview comprised all skill levels of the workforce, from shop floor workers to scientists. In each case we focused on a specific instance of technological change that required upgrading across some or all skill levels of the firms’ workforce, and identified the requisite learning as well as the actual form this upgrading took (see Figure 1).

**Figure 1 – Dynamic human capital/technological upgrading analysis**

<table>
<thead>
<tr>
<th>Before technological change</th>
<th>After technological change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science &amp; engineering skills</strong></td>
<td></td>
</tr>
</tbody>
</table>
- To absorb & build on latest tech, 
- Design & test new products and processes, and keep abreast 
- Keep abreast of basic science 
- Well equipped S&T institutions interact with industry |
| **Management skills** | 
- Operate flat systems with more intense interaction with customers & suppliers 
- Absorb & act upon increasing knowledge flows 
- Encourage investments in innovation & marketing; engage with HQ for increased role in GIN 
- Change traditional HRM & HRD policies to take account of new demands |
| **Engineering skills** | 
- To undertake more advanced functions in product & process design, QM, reliability & cost in new activities 
- Drawing on customers, suppliers, and technology institutions for improvements |
| **Technical skills** | 
- More training for WCM/Lean manufacturing eg team-working, QA, CI, etc 
- Provision of incentives for implementing the best technologies & work practices |
| **Worker skills** | 
- Availability of educated and trained workers with skills relevant to evolving technological needs 
- Flexibility in skills and work attitudes 
- Continuous upgrading and retraining 
- Range of specialized training institutes for particular technologies |

This tool provides a framework for analyzing the skills that are required for a particular case of technological upgrading. Vertically, the table is divided into five areas, depicting skills strata from highest to lowest (from workers to scientists). In each area, the left side of the table represents skills requirements prior to a technical change, while the right side represents skills requirements ex post. Where the dotted line has been reached, the requisite skills were available or were developed during the course of upgrading. Where the dotted line was not reached (at the technical and innovation levels, in this example), a shortage of skills acted as a constraint on upgrading.
Analysis

Each instance of technological upgrading discussed in this section reflects both a strategic decision to undertake a process or product change in a specific location and the availability of the requisite human capital. Ceteris paribus, the closer the change is to R&D as opposed to other forms of upgrading, and the more it takes place in South Africa or India as opposed to Germany, the more evidence there is of a (potentially) evolving GIN. R&D strategies of the case firms range from no to complete offshoring. Elecsys2 undertakes its R&D in South Africa. The German MNEs are more or less reluctant R&D offshorers. Elecsys1 undertakes its entire R&D abroad.

Reluctant offshorers

Drivetraincomp traditionally conducts basic R&D as well as pre- and product development at headquarters and centrally coordinates global innovation activity. It invested in a new R&D centre in the US in the early 2000s and more recently in. Its South African subsidiary only undertakes applied development. For example, Drivetraincomp SA designed a specific drivetrain component for a Japanese OEM. For this contract it interacted directly, not via the parent, with the customer. Its knowledge of local road surface and load conditions allowed it to develop an adaptation of an existing component to the much tougher requirements faced by commercial vehicles in developing countries. Its technology was subsequently passed on to the Brazilian subsidiary.

The South African subsidiary possesses most of the skills required for applied development. Where gaps occur, local engineers make use of the group intranet to access the requisite skills from colleagues in Germany or other countries. For example, they consult with mathematicians and physicists based in Germany with regards to basic research issues, or they can consult with specialists based in Brazil if there is a particular matter of applicability to developing country conditions. Communication is horizontal and does not go through headquarters.

Similarly to Drivetraincomp, Exhaustcomp’s and Tempcomp’s principal R&D facilities are located in Germany. This reflects high local R&D capabilities and the need for proximity to OEM customers. Both companies have development centres in other countries where market size and characteristics warrant and demand adaptation of existing products; Exhaustcomp has four such centres and Tempcomp has 11 in different parts of the world. Driven by cost considerations, both companies opened R&D facilities in Pune, India. These centres now undertake work that used to be done either only by their parent companies themselves, or was outsourced to specialized engineering service firms in Germany. Although some of the offshored work consists of standardized tasks, in both cases this is a departure from their previous practice to retain complex R&D tasks exclusively in Germany.

By contrast, Exhaustcomp’s SA subsidiary is given little leeway in influencing process innovations although local managers claim that they have the necessary capabilities, reflected in significantly lower reject rates. For example, the South African plant reported a reject rate of 60 to 80 parts per million, compared to about 200 in the equivalent German plant. In their interpretation, the existing division of innovation labour is due to group internal hierarchies rather than a reflection of lack of capabilities on their part. The subsidiary is
involved in product innovation only where OEM customers request components for vehicles that are marketed exclusively in South Africa.

**Aggressive offshorers**

Elecsys1 used to be a South African company that produced electronic components for OEMs. As a local company, it was in danger of being substituted by a follow-source supplier. In order to retain access to the OEM market in a longer-term perspective, it needed a development facility that was recognized for its capabilities, specifically to design the components required by the OEMs. Due to the structure of innovation in the automotive industry explained above, such a facility had to be located in a Triad economy. Thus, in the mid-noughties, the firm acquired an engineering services consultancy in Europe, previously owned by an OEM. The acquisition gave it access to one R&D centre each in the European and North American markets. Much like some Chinese OEMs referred to above, the company thus bought assets that were technologically more advanced than its own. The division of labour is that the developed-country operations undertake R&D, whereas the South African operation focuses on manufacturing.

The company now supplies very advanced engine management systems for upmarket vehicles that it develops in-house. Hence it is engaged in R&D that leads to product innovation. This would not be possible without the acquisition. In combination with the advantages of flexibility that characterize the South African operation, the enlarged firm is carving out a niche as a non-Triad first tier supplier to global OEM customers.

**Onkeepers (or whatever the opposite of offshorers is)**

Elecsys2 manufactures electronic components. Although it exports to overseas markets, the firm develops almost all its products in South Africa. It does not do basic research but undertakes applied development on the basis of high-tech components that it sources globally. For example, the firm imported breathalysers from the UK and integrated the technology into an automotive application (an immobilizer). When the market for breathalysers grew and the UK company was not in a position to meet increasing quality standards and higher volumes, Elecsys2 re-engineered the product. At the assembly level, this required very little adaptation because it is essentially a standard process. Components may vary in size and so on, but operators familiar with electronics assembly can easily be trained to make a breathalyser instead. This is a capital-intensive process that minimises human error. Hence, changes in competences are more relevant at the level of engineers, and it is typically they who drive the change in the first place. That is, they suggest a new application and then proceed to designing the requisite process to produce it.

In addition to engineering new products for the automotive sector, the company aims to shift its electronics expertise to applications outside the automotive industry in order to escape the hierarchy and ever-diminishing margins in favour of sectors where it can extract higher rent, for example developing communications and tracking systems for surveillance use.
Upgrading or R&D?

From a certain level of technological capability, most firms do not either only upgrade or innovate, but do both (Hobday et al 2005). In some areas they still re-engineer or adapt, while in others they already engage in new product or process design. But it is possible to distinguish between firms – or their subsidiaries – with new-to-the-world activities, and those that operate at a considerable distance from the frontier.

Both Drivetraincomp SA and Elecsys2 undertake knowledge-intensive activities, and Elecsys2 has significantly increased its research intensity over the past decade. Yet both companies engage essentially in applied development, recombining complex sources of knowledge to design components and systems. Neither engages in basic R&D, nor is it likely to do so in the future. Hence their technological trajectory merely confirms the larger story of upgraded supplier competences in the automotive industries of developing countries over the past two decades. Neither firm faces insurmountable skills constraints. For example, when Elecsys2 develops a new product, the primary skills requirement is at the engineering level. At the assembly level, new products require very little adaptation because the electronic components they produce essentially employ a standard, capital intensive assembly process that minimises human error as much as possible. Hence, skill is less important at the shop floor level, and more important at the engineering level, where the firm manages to find adequate skills. Another example is the development by Drivetraincomp of a clutch for a major Japanese assembler. The primary purpose of this development was to modify the existing design to cope with the rougher and more varied driving conditions in South Africa. In this instance Drivetraincomp had access to the necessary skills to develop the product and successfully bring it to market in South Africa; in addition, the South African designed product was also produced by the group’s subsidiary Brazil.

By contrast, Elecsys1 and the two other German MNEs do engage in activities that are qualitatively different from merely reaching world quality standards. Human capital influences these strategies in opposite ways. In the case of the South African manufacturer, R&D offshoring to Europe is the result of the local absence of the requisite capabilities. In the case of Tempcomp and Exhaustcomp, R&D offshoring to India is manifestly not the local absence of such capabilities in Germany, but their presence abroad at a much more competitive price. In both cases, human capital thus acts as a pull factor.

The management of tacit knowledge

R&D offshoring presupposes the existence of advanced capabilities in the destination country. But in an industry in which tacit knowledge plays a major role in technological progress, the existence of highly qualified engineers and scientists is not sufficient – what also needs to happen is the management of this knowledge across large distances and different time zones.

The reluctant offshorers use cross-cultural communication and the migration of knowledge workers to address this problem (cf. Lehner and Warth 2010). When Exhaustcomp opened an R&D facility in India, the manager was appointed in India, then transferred to headquarters in Germany, where he remained for over a year. There his experience and training included the absorption of tacit knowledge by collaborating in different departments and getting to know the “mindsets” of the researchers at headquarters. In India, he had to
reconcile this experience with the way local processes. He therefore acts as a knowledge bridge between India and Germany. This organisation of learning is used across the group. At headquarters, there are engineers from several countries where the firm is present, some undergoing training before they return to their home countries, others permanently appointed in Germany to be the contact point for the related subsidiary abroad.

Tempcomp faced similar challenges of knowledge transfer between Germany and India, and in response commissioned a knowledge management expert from within the company to investigate possible responses. This formed part of an “action-oriented” PhD project. Their aim was to improve opportunities to relocate design tasks from the German R&D centre to the Indian centre through means of knowledge management, including information technology, the organisation of activities, the content of communication and interpersonal communication. Their findings suggested five main sets of measures. First, one of the main problem areas was identified as intercultural communication. A training course on intercultural communication for German and Indian engineers, hosted by a Tempcomp employee with cultural ties to both countries, was developed and undertaken in both Germany and India. Second was an attempt to codify the tacit knowledge held in Germany for the benefit of Indian staff. This included IT-based guidelines, checklists and procedure manuals informed by experiences in technical problem solving. Third, to improve the familiarity of Indian engineers with Tempcomp’s products and value chain, the firm established short term assignments of Indians to Germany and visiting programmes to suppliers and production plants. Fourth, further organisational rules were implemented in India to overcome internal hierarchical communication barriers. Lastly, the firm implemented a gatekeeper model, transferring three Indian engineers to the German headquarters and having three Germans/Americans at the Indian location to capture the tasks, inform their colleagues (in India) and check the quality of the deliverable.

**Conclusion**

Based on the evidence presented above it is evident that the offshoring of knowledge-intensive activities is beginning to appear in an industry that is known more than others for centralizing most such activity close to headquarter locations, and always in developed economies. It is also evident that this phenomenon is not just based on Northern MNEs taking advantage of advanced capabilities in developing countries. Firms from the South, too, *inshore* the relevant knowledge through acquisitions of strategic assets in the North. As a result, GINs may evolve (see Figure 2).

The experience of the firms makes it clear that strategic intent and the stock of local capabilities are not a sufficient condition for the emergence of GINs. The tacit character of relevant knowledge in the industry, combined with different work practices that, in turn, are influenced by the respective cultural environment, necessitate dedicated knowledge management in the context of cross-cultural communication. The difficulties of such communication are related to the distance, cultural and otherwise, of firms from different backgrounds. For obvious reasons they are larger between a European and an Indian firms than between, say, a South African and an English firm.
The management of knowledge transfer is key because owning a knowledge asset is not equivalent to know-why, much like JVs do not guarantee knowledge transfer from the senior to the junior partner, as hoped for in policies incentivizing equity partnerships between foreign and local firms (Sadoi 2008). For example, although Elecsys1 now owns advanced engineering capabilities, it has not yet internalized these competences. Doing so takes time, and in this industry it is likely to require more time than in others where knowledge is more codified. The same applies to the Chinese and Indian OEMs that have acquired European or US carmakers.

The education and skills system obviously influences average capabilities and is thus an important indicator of the attractiveness of a region or a country for knowledge-intensive investments. But the more relevant finding is that firms in economies with severe human capital constraints at lower and medium levels can manage technical change, including new-to-the-world innovation, by exploiting high-level capabilities while adjusting to lower-level skill constraints through dedicated process engineering.

Finally, opportunities for GINs are larger in large-high-growth markets. Ceteris paribus, the evidence has shown that India is more likely to be part of automotive GINs than South Africa, despite the fact that its relevant competencies are currently not necessarily higher.

Automotive World Automotive Passenger Car OEM Quarterly Data Book, 2009


Ivarsson, I. and Alvstam, C.G. 2005, "Technology transfer from TNCs to local suppliers in developing countries: a study of AB Volvo’s truck and bus plants in Brazil, China, India, and Mexico", *World Development*, vol. 33, no. 8, pp. 1325-1344.


Appendix – Response rates and total sample distribution by sector, country and firm size.

<table>
<thead>
<tr>
<th>Sector/country dataset</th>
<th>responses</th>
<th>response rate (%)</th>
<th>% over total sector obs.</th>
<th>R&amp;D active firms</th>
<th>% of R&amp;D active firms over national sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>9119</td>
<td>2.7</td>
<td>26</td>
<td>181</td>
<td>74.5</td>
</tr>
<tr>
<td>Estonia</td>
<td>121</td>
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<td>2</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>519</td>
<td>34.5</td>
<td>19.1</td>
<td>53</td>
<td>29.6</td>
</tr>
<tr>
<td>India</td>
<td>1287</td>
<td>25.2</td>
<td>34.7</td>
<td>195</td>
<td>60.2</td>
</tr>
<tr>
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<td>1662</td>
<td>10.3</td>
<td>18.3</td>
<td>76</td>
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<td>60.7</td>
<td>376</td>
<td>66.3</td>
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<tr>
<td>China</td>
<td>210</td>
<td>23.3</td>
<td>37.1</td>
<td>5</td>
<td>10.2</td>
</tr>
<tr>
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<td>2</td>
<td>1.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>325</td>
<td>24.9</td>
<td>61.4</td>
<td>27</td>
<td>33.3</td>
</tr>
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<td>Total EU</td>
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<td>24</td>
<td>38.6</td>
<td>5</td>
<td>9.8</td>
</tr>
<tr>
<td>Total emerging</td>
<td>325</td>
<td>24.9</td>
<td>61.4</td>
<td>27</td>
<td>33.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>49</td>
<td>28.6</td>
<td>46.6</td>
<td>17</td>
<td>24.6</td>
</tr>
<tr>
<td>Norway</td>
<td>2</td>
<td>1.4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>325</td>
<td>24.9</td>
<td>61.4</td>
<td>27</td>
<td>33.3</td>
</tr>
<tr>
<td>Total EU</td>
<td>1131</td>
<td>6.8</td>
<td>52</td>
<td>44</td>
<td>57.1</td>
</tr>
<tr>
<td>Total emerging</td>
<td>243</td>
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<td>48</td>
<td>17</td>
<td>23.9</td>
</tr>
<tr>
<td>Brazil</td>
<td>241</td>
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<td>46.6</td>
<td>17</td>
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</tr>
<tr>
<td>Germany</td>
<td>963</td>
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<td>31</td>
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<tr>
<td>South Africa</td>
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<td>Sweden</td>
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<td>16.2</td>
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<td>6.8</td>
<td>52</td>
<td>44</td>
<td>57.1</td>
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<tr>
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<td>Germany</td>
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<tr>
<td>South Africa</td>
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<td>1.4</td>
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<tr>
<td>Sweden</td>
<td>168</td>
<td>14.3</td>
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<tr>
<td>Total</td>
<td>14620</td>
<td>8.3</td>
<td>600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The Chinese sample was extracted from two regional databases: (i) the Beijing database and (ii) the Schenzhen database. The questionnaire was distributed in the five most developed provinces in China: 146 questionnaires came from Beijing, which account for 60% of the total questionnaires; 51 came from Guangdong province, which account for 21%; 35 from Shanghai, 14%, 10 from the Zhejiang province, representing the 4%, and only 1 from Shandong province.

2 The Indian sample was extracted from the NASSCOM Directory of IT firms 2009-2010, distributed across the main cities and regions as it follows: 281 in Bangalore, which account for 21.8% of NASSCOM Directory; 256 in Delhi/Noida/Gurgaon representing the 19.9%; 185 in Mumbai(14.4%); 72 in Pune (5.6%); 147 in Chennai (11.4%); 184 in Trivandrum (14.3%); 107 in Hyderabad (8.3%) and 55 in Kochi (4.3%).

3 The Brazilian sample was extracted from the Annual Registry of Social Information (RAIS), a registry of social and balance sheet information collected by the Brazilian Labour and Employment Ministry. The total number of firms classified in the automotive sector in Brazil is 2,625. Out of these, 233 companies are located in the state of Minas Gerais and, of these, 107 (46%) have employed, in 2008, 30 workers or more. From the dataset all automotive firms from the state of Minas Gerais were selected, provided the firm declared over 30 employees.