From the Phased Manufacturing Programme to Frugal Engineering: Some Initial Propositions

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Although the structural reforms, initiated in 1991, did not lead to any appreciable increase in either the efficiency or the export orientation of Indian manufacturing firms, unexpectedly, there has been a visible improvement in manufacturing design capabilities in certain segments, for instance, in the motor vehicle sector. The paper suggests that the development of "frugal engineering"—an approach of "frugality" in resolving complex design problems—is a real advance. It suggests, further, that this approach developed from the experiences of the procedures laid down in the phased manufacturing programme of the 1950s, and first found expression in the successful forays into some specific export markets by Indian vehicle manufacturers in the late 1970s and 1980s. Although this design expertise cannot solve the problems of manufacturing efficiency, particularly across the wider industrial sphere, it indicates that Indian firms have the expertise to resolve problems related to the manufacturing sphere if strategic goals are appropriately set by managers.

Frugal Engineering: The Latest Managerial Fad?

Frugal engineering predated frugal innovation to describe, in somewhat the same way as reverse engineering, norms of engineering practice in Indian companies designed to lower the cost of product development and manufacturing.[1] Carlos Ghosn, the chief executive officer of Nissan and Renault, is usually attributed with the first use of the term (Radjou et al 2012). In mainstream management circles, frugal engineering was highlighted by the *Economist* (2010a, 2010b).

Frugal innovation has arisen not from the writings of academics or experts but out of management responses to unique economic, social and competitive challenges faced by firms in developing countries. There are no generally accepted guidelines or simple rules for all to follow on how frugal innovation can materialise into any perceived or promised results. Frugal innovation, as it stands, seems to be complex, multifaceted and can be interpreted and applied in a number of ways in different firms (BS 2012).

With management literature first outlining the frugal innovation space, and now subsequently being followed by research and empirical concerns by the academic community, the dominant view may be defined by the management community. However, to make it a good "fit" for organisations to effectively imitate or adopt notions of frugal innovation strategies, academic research is needed to help define its full potential as well as limitations. For instance, towards the end of last century, "lean" processes based on eliminating waste (for example, lean engineering and just in time manufacturing) diffused from Japan's Toyota Production System (TPS) into mainstream firms. The lean concept stems from the Japanese management and Total Quality Management literature.

The Legacy of Lean Practices

Lean manufacturing is emerging as the dominant paradigm for the design and operation of current manufacturing facilities. Lean is usually understood to be relevant to the "operations" of a manufacturing enterprise, meaning those processes associated with material supply, component production, and delivery of products and services to the customer. However, "lean thinking" can also be applied outside manufacturing operations, although examples of this, such as applications in service-based enterprises, are relatively rare. Knowledge-based activities such as design, new product introduction

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(NPI), engineering, and product development (PD) are areas within an enterprise where the potential benefits from the adoption of Lean principles may be significant.

Western companies tend to focus on Lean through the application of tools and techniques, whereas their Japanese counterparts talk of philosophy and culture. The philosophical perspective is a multidimensional approach affecting the entire organisation in every function and encompassing a wide variety of management practices—just-in-time, quality systems, work teams, cellular manufacturing, supplier management—in an integrated system. Whatever the perspective, the elimination of waste is the principle that has traditionally been at the heart of the Lean approach. In the case of Toyota, the PD system has been the key to success and Toyota's Lean manufacturing system is actually an extension of their product development philosophy and not the reverse. However, most firms are focusing their Lean initiatives at manufacturing operations with few attempts to adopt Lean in design-related activities.

There is a wide variety of examples—such as software, construction and aerospace—where Lean has been applied. In software, the consideration of the waste principle addresses the shortening of long information feedback loops, the existence of which is cited as the reason why over 50% of all newly developed software is seldom, if ever, reused. The result of shortening feedback loops creates flow, increases speed and quality, and hence reduces cost and adds value. The major implementation issue here was the requirement for deep changes in the way organisations are managed. Within the construction industry the Lean principle of waste elimination in the design process is conceptualised as a flow of information, which lends itself to waste reduction through minimising the amount of time before information is used. Value generation arises from capturing the customer's requirements and transmitting these accurately in the overall design process. In later work the analogy between the roles of information in the PD value stream and material in manufacturing has been noted.

The first principle of Lean is to "specify value," which can be stated as: "A capability provided to a customer at the right time at an appropriate price as defined in each case by the customer." However, when applying these principles to PD it is recognised that waste is much more difficult to identify than in a manufacturing environment. In manufacturing, excess inventory or work in progress (WIP), which is considered a form of waste, is physically and financially visible. However, in PD the WIP inventory is generally in the form of information. As a result of work carried out as part of the US Lean Aerospace Initiative, it was argued that the usual definitions of value did not provide the necessary precision when applied to identifying the root causes of the waste that is present in most PD processes. Value is added in PD when useful information is produced. The value of this information can be to increase certainty or reduce risk. Value in the PD process can be created by adding as well as taking away activities.

Set-based concurrent engineering (or set-based design), as practised by Toyota, is suggested in as the preferred approach to Lean PD. Set-based design imposes agreed constraints across different functions to ensure that a final subsystem solution, chosen from a set of alternatives from a particular function (such as body, power train, engine management) will work with convergent solutions from all other functions. During the design process as each alternative is evaluated, trade-offs are made, weaker solutions are eliminated, and new ones are created, often by combining components in new ways. Redundancy is built into the system, radically reducing risk. Instead of being designed from the top down, the actual system configuration evolves.

The generation use and reuse of knowledge/information are the key to a successful adoption of Lean in PD. Standardised concurrent engineering techniques are effective in sharing and reusing knowledge/information at the detail design phase. This sharing of design (and manufacturing knowledge) across the product introduction process is viewed as a knowledge management problem. The challenge is in ensuring that the information is structured in such a way as to make it communicable between systems. Systems for controlling documents, central databases, knowledge-based systems, project management systems, CAD (computer-aided design)/CAM (computer-aided manufacturing)/CAE (computer-aided engineering)/PDM (product data management) systems, and web-based data-sharing and communication tools can all be used to facilitate Lean.

TELCO's Technological Ascendance

The Tata Engineering and Locomotive Company (TELCO) was incorporated in September 1945 at Jamshedpur following Tata Sons taking over the Singhbhum Shops from East India Railways in June 1945. Started with the objective of producing locomotives and general engineering equipment, TELCO's first locomotive was produced in 1952 (Bowonder 1998: 646–47). Subsequently, it collaborated with Daimler-Benz for the manufacture of trucks and buses and was permitted to manufacture three to five tonne diesel vehicles. It was envisaged that the engine would be manufactured at the end of the last stage, in 1959. Daimler-Benz had 10% equity stake in TELCO.

As there was need for expansion of capacity, TELCO started a new motor vehicle manufacturing unit at Pune in 1965. To establish a technological base for indigenous capability it acquired the long-established Investa Machine Tool Company. This unit supplied the machine tools needed by TELCO. The starting of a design centre in 1967 when no major Indian firm had any research and development (R&D) activity showed the importance given to design and new product development (Bowonder 1998: 649). In fact, it was asserted that in TELCO's philosophy, as in that of Daimler-Benz, a truck or an automobile was primarily a high-grade technical product with a commercial content and not a piece of merchandise which happened, unfortunately, to have a technical content (TELCO 1969: 1243–44).

This remarkable statement of manufacturing philosophy was made by the chairperson, Sumant Moolgaokar (1906–89). Equally remarkable was his assertion, made as early as 1953, that the government was the only agency through which the productive efficiency of the manufacturing sector could be increased (Moolgaokar 1953). Moolgaokar was an engineer trained at the City and Guilds Institute and Imperial College, London. In the pre-independence period he had worked in the cement industry and helped develop the manufacture of cement machinery during the World War II. After the formation of TELCO in 1945, he was closely associated with its development until his death. He played an active role as a consultant in planning the development of the heavy engineering industry, notably in conducting a benchmark survey of existing engineering capacity in the country in the mid-1950s (India 1954).

For some years before the end of the collaboration agreement there had been no Mercedes-Benz vehicle identical to the Indian product because of various modifications and improvements incorporated in the Tata Mercedes Benz (TMB) vehicle to make it suitable for the difficult road and operating conditions in the country. By the time the 15-year agreement between TELCO and Daimler-Benz expired in March 1969, the Press Tool Division at Pune was in full production; the complex tools and dies produced there eliminated dependence on imports for current operations and also provided the tooling for the future (TELCO 1969: 1243–44). The facilities of the Machine Tool Division at Pune, as a result of an agreement with Rheinstahl Henschel AG, West Germany, enabled TELCO to produce indigenously the large number of special purpose machine-tools needed for replacing and modernising the equipment of the Automobile Division at Jamshedpur, most of which had been operating continuously for many years (TELCO 1968: 1189–91).

The manufacture of steam locomotives at Jamshedpur, first begun in January 1952, ceased in June 1970 on the termination of the Company's commitment to the Railways. The Company had implemented plans for the utilisation of the workers and plant facilities released by the cessation of locomotive manufacture (TELCO 1970: 1309–11). New products, including tippers, forklifts and dumper placers, developed by the Company's research and development engineers, were being produced in the shops previously engaged in locomotive manufacture.

Reconditioning and Redesigning Old Equipment

Many plants in the country, in many industries, had been allowed to deteriorate through neglect, either overworked for quick profits, or badly maintained, so that their capacity decreased in the course of time. In TELCO it was recognised that the size of the assets of a Company did not determine the Company's capabilities of production, especially on a continuing basis (TELCO 1973: 1258–60). Great attention was paid to the maintenance of equipment, the reconditioning of old equipment and replacement of worn-out machines. Large shops both at Jamshedpur and Pune for reconditioning and redesigning old equipment, and the Machine Tool Division at Pune were actively meeting a significant part of the Company's requirement of replacement machines which were hitherto imported. Import of machine tools had become increasingly difficult and very costly, and indigenous manufacturers were not able to meet requirements fully, especially for the more sophisticated special purpose machines.

It was not only through new models that technological development was expressed through the benefit of design and development efforts. Existing models were being continuously upgraded to attain higher standards of performance and to fuel-efficient, rugged and abuse-proof product with low lifecycle costs (TELCO 1982: 1276–77). Moreover, engineering developments in TELCO were not merely restricted to improvements in products. The automotive industry drew upon a multitude of complex, fast-changing technologies where know-how was being developed at an ever-increasing rate. Superficially, it would appear attractive to acquire such know-how merely through buying the latest but this was not to be the path best suited for long-term needs (TELCO 1984: 1180–81). The longer and harder route of training workers who were capable of absorbing the latest technology and giving them the facilities needed for their development would ensure that the upgradation of technology became an inevitable component of growth in general. Such an approach did not exclude the import of existing technology or even of component knocked down packs to start with. This was the model TELCO was encouraged by the government to adopt.

Upgrading the manufacturing facility had been a major element of TELCO's strategy. Along with the introduction of new manufacturing technologies, testing facilities were upgraded (Bowonder 1998: 663). The focus was on continuous improvement of productivity, quality and manufacturability through automation. In order to produce the 407 series of light commercial vehicles (LCV) in a targeted time frame, TELCO installed a number of computer numerical control (CNC) and milling machines. A new electronics centre was established at Pune to support the manufacture and maintenance of CNC machines. These contributed to the establishment of a base for a higher level of flexibility.

Once the 407 series of LCV production started, the development of the heavier 608 series began. Manufacture of CNC machines with collaboration started during 1986–87 (Bowonder 1998: 663). TELCO started retrofitting sophisticated control systems on older machines as part of its reconditioning and modernisation programme. In 1987–88, a machine reconditioning programme was started as a part of the continuous plant rejuvenation efforts. After initiating steps for introducing the 608 series of LCV, the next major effort was to develop production facilities for the 206 series pickup vehicles.

Because of the entry of global players, TELCO found it necessary to increase the level of automation. In 1994–95, for the first time in the country, TELCO produced three basic robots in collaboration with Nachi–Fujikoshi of Japan (Bowonder 1998: 663). These were: spot-welding robot, sealant application robot, and arc-welding robot. The continuous improvement of manufacturing systems, increased automation and retrofitting of older equipment had been major thrusts. The product development efforts and manufacturing technology improvements were done in a matching manner so that productivity never lagged.

The pool of technical talent engaged in various activities constantly interacted with vehicle designers. A vehicle concept was thus developed by the vehicle design engineers through an intensive cross-flow of information from the marketing, testing, engineering, and production and service functions (TELCO 1988: 1672–73). It was this simultaneous engineering that had permitted speed up in the introduction of new vehicles. The traditional sequential procedure would have added years to the product introduction cycle. The best ideas available internationally, with those from engineers in different disciplines, as also suppliers and customers, contributed to the final design.

TELCO devised a strategy which used indigenous competence along with acquisition of technology from abroad (Bowonder 1998: 657). Most of these collaborations had been in the area of manufacturing process technology. The transfer of manufacturing process technology and rapid learning of competencies for new product engineering helped TELCO to become technologically competitive.

Resource Acquisition Strategy in Passenger Cars

After a longer period of organic and incremental growth TELCO was hit by a cyclical 40% shrinkage of the Indian CV market in 2000–01 which triggered a transformative phase of restructuring, process improvements and rejuvenation of its management, preparing the ground for bolder strategic initiatives in the future (Bruche 2010: 6). While TELCO's high degree of vertical integration was a boon in better times, this very factor was responsible for the Company's underperformance in trying times. While it reaped the benefits of producing virtually all its components in-house, the advantage turned into its Achilles heel when the going became difficult with the adverse situation magnifying itself all along the value chain (EPW 1999: 2284). In an attempt to deal with the cyclical demand patterns in the commercial vehicle industry, the Company planned to apply a strategy to transform itself from a domestic commercial vehicle maker to an automotive company. TELCO also adopted outsourcing and moved away from high levels of vertical integration (EPW 1999: 2284).

The focus of competitiveness had shifted from manufacturing capability to product development. Supply chains were increasingly driving manufacturing activity with efficient assembling as the focus of attention (Bowonder 2004: 292). This meant that product variety, product platforms, product development flexibility and product development cycle time were becoming the differentiating elements in competition. With the growth of the commercial vehicle market slowing down, global competition had essentially focused on the car market—the medium and the low-end market.

The entry of the renamed TELCO, Tata Motors Ltd (TML), into passenger cars, its ascent as a relevant domestic player and its recent internationalisation of sales and manufacturing in the passenger car segment had been underpinned by an intricate asset acquisition, accumulation and organisational learning process (Bruche 2010: 7). In hindsight, four distinct but overlapping phases of this process could be discerned which were sometimes triggered by external events and usually driven inside the company through strategic initiatives or projects. The phases were not results of a grand strategy, but rather the outcome of a strong intent to overcome a situation of backwardness coupled with an evolutionary search under a changing institutional context and internal resource conditions.

When the management of TML decided to enter and compete in the passenger car segment it relied to a considerable extent on strategic assets and capabilities built during its history as a pure CV manufacturer. Long before TML entered the passenger car segment in the early 1990s the Company had taken some steps to extend its technological base and upgrade its capabilities in automobile design and manufacturing (TELCO 1969: 1243). The establishment of an Engineering Research Centre at Pune in 1967 facilitated the creation of an internal engineering force which would increase TML's absorptive capacity for external technologies and create a basis for indigenous product development. A more immediate facilitating condition was the antecedent development and manufacture of LCVs (the 407 model launched in 1986, followed by the Tata mobile pickup in 1988) which provided a platform, engine technology, and manufacturing as well as tooling capabilities for the entry into passenger cars (TELCO 1989: 1824).

The initial entry of TML into passenger cars relied on an incremental extension or resource leverage from its light commercial vehicles as both the Sierra (launched 1991) and the Estate (launched 1992) were built on the platform of the pickup (Bruche 2010: 8). As B Bowonder, Director at Tata Management Training Centre, writes in his account of the TML's small car development project: "the learning needed for making a car essentially started with the pickup vehicle 207" (Bowonder 2004: 300). While the initial entry was focused on the large car segment it had become increasingly clear that the Indian passenger car market would for the foreseeable future be a small car market. After market analyses and feasibility studies TML started in 1994 its attempt to develop the first Indian small car for the domestic market, the Indica. The car was to be positioned as a competitor to the market leading Maruti 800 of the Japanese car maker Suzuki. In terms of its principal approach in the Indica project, TML

> adopted the philosophy that all components critical to the car business were not to be sourced but should be produced internally. Specialised products were to be procured, especially those available in the market. Products for which suppliers had to make substantial investments would be done through joint ventures. Finally, generic components would be procured from good suppliers in India. With this in mind, critical capabilities needed from a long-term perspective were identified. Potential partners were identified for all critical components not available. This was done keeping in mind that the alliance relationship should give Tata Motors some inherent learning value (Bowonder 2004: 310).

The development process involved some 700 engineers and cost, including tooling and setting up of production facilities, $400 million, compared with well over $2 billion such a process would cost in a developed country (Bruche 2010: 9). TML also established a new organisational structure for tiered supplier management and entrusted the Tata Group affiliate Tata Automobile Components (TACO), newly formed in 1995, with this task. In the time span of only four years TML significantly improved its capability to manage automobile development projects and used the significant learning opportunities to expand its organisational as well as staff-level skill sets. The physical proximity of R&D, tooling and production in one place (Pune) were an advantage in building the complex concurrent engineering capabilities needed in automotive development projects (Bruche 2010: 9).

The Nano Project

TML was weak in technological capability, especially in product development capability. In 2003, when a project was started as an advanced engineering project, the objective was to develop a car that would be "ultra cheap" (Lim et al 2009: 16). The commercial project for the car was initiated in 2005. The team was given a base model product and the target price of $2,500 and minimum requirements of performance. This investigative process was guided by the three parameters: acceptable cost ($2,500 price level), acceptable performance and regulatory compliance (safety and environmental regulation). The lean product development (LPD) process is initially a reverse process of exploring a given product concept to achieve a drastic reduction in cost while adhering to the design parameters.

PD activities are stretched to reduce cost in manufacturing. According to V Suhasrabuddhey, divisional manager, Small Car Project Office, they did an exercise called the design for manufacturing and assembling whereby the design efficiency of each of the assemblies was examined (Lim 2009: 18). Some of the car's design, even though the car's design is basically an integral design, was made modular, so that the car could be built and shipped in segments to be assembled in different locations. This also implies that the PD process had considered cost reductions for the manufacturing process. The lean design principle was stretched to vendor management. The suppliers participated in developing components with reduced cost at an early stage of product development. It is known that value analysis and value engineering had been diffused to the major suppliers in India. Suhasrabuddhey mentioned the suppliers' participation in LPD.

The main cost components of a car were its power train (consisting of the engine, transmission, drive shafts, clutch, and axle) that typically accounted for 25%–30% of a car's total materials cost; rolling chassis items (the wheels, brakes, and steering) that contributed another 20%–25%; and the remainder spread over body parts and trim (Palepu et al 2011: 6). Roughly, 70% of suppliers were local, and 30% foreign. In aggregate, 85% of the car by value was outsourced. Internally, Tata engineers played a key role in the overall design as well as on particular components. One such component was the engine. More than half of the components were proprietary parts designed by suppliers themselves (Palepu et al 2011: 7).

> The entire system was being re-invented. Innovation at the aggregate level trickled down to system, then to sub-systems, then to parts. We went through a tremendous amount of iteration in the design process. The entire engine was redesigned thrice, the entire body was redesigned twice, and the floor plan of the car redesigned around 10 times, the wiper system redesigned more than 11 times. In any other project, you very clearly define the layout and targets, and work towards it where execution excellence comes into play. Whereas here, it was more of iterating with design, re-defining targets as we were moving on, and working with suppliers through the re-designs (Girish Wagh, Nano Project Head quoted in Palepu et al 2011: 8).

Again,

> we instituted frequent sessions to bring everyone together. Every morning a group of us—sometimes up to 30—would meet for sessions lasting as long as four hours, an entire morning where we would express concerns and issues, challenge assumptions, appreciate failures, celebrate achievements, and recognise delays. More important, bringing the team together allowed us to take decisions fast. Since there were so many iterations, delayed decisions would have been very costly. There were many young people in the team who had a lot of humility to learn.

Although a new organisation was created drawing primarily from lateral recruits rather than internal TML personnel, the project team leveraged expertise more broadly from within TML, too. Assistance from the commercial vehicle arm was sought to identify ways to lay alternate fuel lines, make better use of plastics, or build better lamps (Palepu et al 2011: 5, 9).

TML had a strategy of active utilisation of three-dimensional CAD to support the PD process. This made it possible to build prototypes digitally, perform certain tests with simulation exercises, and perform evaluations. According to an engineer from a consulting company that had advised TML on the use of digital technology, the design process for the Nano was an advance on that for the Indica in terms of computer aided design, digital mock-up, digital validation for final assembly, digital validation for body, and digital factory modelling (Lim et al 2009: 22).

Transfer of Frugal Engineering Expertise

One of the major foreign component suppliers for the Nano was the Bosch Automotive Group, a German automotive ancillary known for engineering excellence. Dr Bernd Bohr, Chairman of the Automotive Group, described the project environment inside Bosch:

> Tata did not come to us with large rulebooks or specifications. They simply told us what the weight of the car would be, that it would have a two-cylinder engine, and would need to achieve Euro 4 emission regulation. In addition, it needs to drive, of course. And that was the major difference from other auto projects or customers.
>
> Early in the process, one could already see that our teams were coming up with new ideas that created a kind of self-momentum. Where usually one would say that cost reduction is not so exciting for an engineer, here we really had teams having fun. For example, typically each cylinder has an injection valve on an engine; here, our engineers came up with the idea of saying, let us have one injection valve for two cylinders and give two spray holes so that it takes care of two cylinders. On the software side, a typical electronic control unit (or ECU) for a middle-class car in Europe would have 5,500 parameter groups; for the Nano we have 1,700. With that complexity out of the system one can have a smaller processor, less power consumption, and so on. Similarly, the idle speed control, which keeps the engine at the same rest when you are idling, has over 100 parameters you can adjust in a typical car. The Nano has seven. Maybe in some cases the RPMs would vary by 10 or 20 RPM, the engine will still not stall, and 99% of drivers would not notice. But that's the kind of 'perfection' that has accumulated in control systems over the years.
>
> Questioning things we have taken for granted is useful. We are now using low-price vehicles as a training and learning ground to do things simpler. In terms of technical innovation itself, I would probably put this project at a five or six. There were some things like pushing diesel injection from 2000 to 2500 bar, coming up with new materials and new laser machining processes, where it would be an eight or nine. However, the major challenge was getting across the cost barrier while doing all this. That would be a 10 (Palepu et al 2011: 7).

Bohr emphasised that while Bosch would not "buy" itself into this market segment and the margins that they expected were similar to that on large volume European projects, they anticipated a learning experience. This would later be transferred to products for their European, American, and Japanese customers. He claimed that there were already early success stories of this transfer. It was for the first time that Bosch was proud of having designed cost reduction (Palepu et al 2011: 8).

The Nano development project was also achieved in close cooperation with Tata Technologies Limited (TTL). INCAT is an operating company of TTL. The company was a British engineering company until 2005, when it was acquired by the Tata group. INCAT's services include product design, analysis and production engineering, and product-centric information technology (IT) services including IT services for the digital tools supporting product development. It has a cooperative relationship with Dassault system, UGS, and Autodesk, companies that provide PD digital technology. Its employees number 3,000 globally, and it has engineering centres in North America, Europe, India, and Thailand. INCAT has been involved with the development of the Nano from the start and had worked with "a significant number" of Nano's suppliers.

Conclusions

The organisation of R&D in TELCO from 1965, the formation of Tata Technologies initially in TELCO in 1989, its separation as a subsidiary in 1994, and the acquisition of INCAT in 2005 are all identifiable stages in the organic and acquired growth of technological capability within TELCO, later TML, and within the Tata Group as a whole. The movement of innovative capabilities in manufacturing processes which preoccupied TELCO during the 1970s and 1980s found fruition in the product development expertise exemplified by the introduction of the Indica, Ace, and Nano. Although the Nano project was considerably aided by the expertise embodied in INCAT, what is of note is the absorption of lean design capabilities within Tata Technologies and its transfer to consultancy projects in advanced manufacturing projects and even to its sub systems suppliers (BL 2013; BS 2010).

This paper has concentrated on the evolution of technological competence in TELCO/Tata Motors and Tata Technologies. This is largely because of the greater attention paid to developments in these firms in the management literature, if not yet in the academic field. However, there are indications that other Indian firms in the automotive sector share these attributes (BS 2012). And this allows for the conclusion that not only is there a generic competence embodied in what has been termed frugal innovation, but that the stage of import substitution and the phased manufacturing programme did indeed provide the basis for this now internationally accepted achievement (KPMG 2011; Bound and Thornton 2012).

NOTE

1 It has been claimed that in the pharmaceutical industry, transnational corporations "over-engineer" the R&D process and that even such firms which focus so closely on performance should include the costs of innovation in their strategies (Bhatti and Ventresca 2012: 7 quoting Ryans 2008: 9).

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