In: Emerging Markets: Identification, New Developments… ISBN: 978-1-61668-160-9
Editor: John V. Reynolds © 2009 Nova Science Publishers, Inc.

Chapter 4

PRODUCT ARCHITECTURE AS A DRIVER OF BREAKTHROUGH STRATEGY: THE CASE OF CHINESE CARMAKERS

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ABSTRACT

This chapter will explain how changes in product architecture have become the driving force behind a breakthrough strategy that has enabled Chinese automobile manufacturers to produce vehicles that are broadly equivalent to their western counterparts but at a fraction of the price. It will trace the evolution of this strategy, which is based on an innovative product architecture termed quasi-open modular product architecture. It will illustrate the emergence of this phenomenon through a longitudinal case study of one manufacturer, the Geely Automobile Co. Ltd, which covers the period between 1998 and 2008. The case study will show how this strategy has allowed Geely to move from being a manufacturer of refrigerators and motorbikes to the ninth largest automobile manufacturer in China in a little over 10 years. The chapter will conclude by discussing the strategic potential of innovations in product architecture in general and the role of the specific market conditions in China as a source of potential drivers for breakthrough strategies and product innovation.

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1. INTRODUCTION

Great oaks from little acorns grow and several of the great multinational motor manufacturers seem to have started their lives in the most unlikely of settings. For example, Vauxhall began life in 1857 as the Vauxhall Iron Works and built pumps and marine engines before branching out into automobiles in 1903. Peugeot fabricated ironmongery, coffee grinders and umbrella frames before it began manufacturing bicycles in 1876 and later started producing automobiles. Opel began by producing sewing machines and bicycles before assembling its first automobile in 1899. Toyota started to produce wooden handlooms for the textile industry in 1890 before beginning car production in the 1930's. A century later Geely Automobile Co. Ltd, a Chinese manufacturer that originally produced motorbikes and parts for refrigerators has made a similar transition and, seemingly against all the odds, has grown to be a major manufacturer of automobiles.

Today, American, European and Japanese car manufacturers dominate the world market, yet in less than 15 years, Geely has gone from nothing to become the ninth largest automobile manufacturer in China and thirtieth largest in the world, producing 221 thousand cars a year in 2008. Apart from the scale of the transition, Geely's story is by no means unique in China. Despite the current financial downturn, which has pushed much of the world's automobile industry into crisis, the Chinese automobile industry is booming. While manufacturers serving the US market, including strong performers like Toyota and Honda, have experienced a double-digit decline in their sales, in 2008 the Chinese automobile industry overtook the US to become the second largest in the world, producing 9.4 million vehicles.

Foreign manufacturers located in China have played their part, but local players such as Geely, Chery and BYD have also had a role in this expansion. This article will argue that the rapid growth of indigenous Chinese automobile manufacturers is not driven by low labour costs, but by innovations in product architecture that have allowed Chinese carmakers to develop an innovative production strategy that western manufacturers find hard to follow. It will show how changes in product architecture have enabled Chinese automobile manufacturers to have a low production costs while still producing products that are broadly equivalent to those produced by foreign companies. It will also show how the specific cultural and economic conditions in China favoured the emergence of such a strategy.

The remainder of the chapter is organized as follows. Section 0 outlines the notion of strategic innovations in general and breakthrough strategies in particular. It provides both an illustration of a breakthrough strategy and a definition that will be used in the rest of the chapter. Section 0 builds on this to describe the notion of product architecture as a way in which product design can lead to a breakthrough strategy. In addition to defining product architecture, this section will also introduce the work of Takahiro Fujimoto (Fujimoto, 2002, 2007) who identified the particular form of product architecture used by Chinese automobile manufacturers. Following a brief review of how product architectures in the automobile industry have changed, we present out case study in section 0. The case study is a longitudinal study that took place over a 5 year period. The data gathering methodology is described briefly but the bulk of this section is devoted to the case study company's background and the analysis of the study itself. The chapter concludes by discussing the role of innovation in product architecture in general and the part played by the social and economic conditions in China in the success of the Chinese automobile industry in creating such innovations.

2. BREAKTHROUGH STRATEGIES AND PRODUCT DESIGN

As we indicated above, the success of Chinese automobile manufacturers has been spectacular, particularly when viewed against the problems of the economic crisis that started in late 2008 and disrupted trade across the world. However, perhaps what is most interesting and significant about this is not the fact that it is happening but the reason it is happening. We will argue below that the growth among Chinese automobile manufacturers is not, as some would suppose, driven simply by low labour costs, but is a result of a series of novel strategic innovations in product design that have allowed them to make significant cuts in production costs without a significant reduction in quality.

The notion of being able to make strategic innovations to gain competitive advantage has amassed a body of literature dedicated to the ways in which this can be achieved and the forms it might take (e.g. Charitou & Markides, 2003; Govindarajan & Gupta, 2001; Kim & Mauborgne, 1999; Schlegelmilch, Diamantopoulos, & Kreuz, 2003; Tucker, 2001). In this chapter, we will not explore this literature in detail but simply sketch an outline of the key concepts that are most relevant to our topic.

Strategic innovations are described in a variety of ways by a variety of authors. Although the details of the definitions vary, most authors agree on certain key points:

- Strategic innovations are not about playing the existing game better, but about changing the rules of the game
- Strategic innovations involve a complete reconceptualization or reconfiguration of an existing business model
- Strategic innovations produce a radical or fundamental change in the ways in which things are done

Pin, Métais and Dumoulin (2003) highlight two distinct forms of strategic innovation: a change in the value proposition for the customer and a change to the company's value chain. They argue that a company can produce a successful strategic innovation through either making a change on the customer value axis or on the company value chain axis, in such a way that they succeed in 'disrupting' the way the existing game is played and so create a whole new set of rules that only they fully understand.

For example, budget airlines have placed the attributes that the customer actually values at the core of their strategy and have stripped away the attributes that their competitors had previously perceived as being core values. The result is that they attract new business while the existing airlines struggle to readjust and understand the new way of doing business. Similarly, in the PC market, Dell's direct sales model allowed it to save the margin that would normally go to the dealer. This, coupled with a production system that allowed them to produce a PC 'to order', meant that Dell could produce a PC more cheaply and adjust its production to meet market demands without incurring additional costs. Other manufacturers that relied on traditional production networks and distributors were simply unable to match Dell's cost and flexibility. Breakthrough strategies represent a third category of strategic innovation, where a company is able to combine the two disruptive strategies outlined above.

Examples of this are less common and are more often found in newly created companies in the high tech sector; one of the most frequently cited is that of eBay. eBay operates on the

same general principles as long established auction houses such as Christie's (established in 1766) and Sotheby's (established in 1744) but made a radical departure from the established way of doing things by holding its auctions entirely on-line. The original model for auctions was based on the idea that, in order to attract the maximum number of potential buyers and get the best possible price for the each item, a large number of goods needed to be brought together in one place. eBay uses the same logic of centralization but has updated it by holding its auctions 'on the web'.

By doing this, eBay is freed from the cost of organizing and managing a physical event. As it no longer needs to deal with the problem of managing physical goods, it is able to charge a lower commission and yet still remains profitable. Similarly, by encouraging users to use PayPal for transactions, eBay is able to generate an additional revenue stream. Consequently, eBay has been able to trim its value chain and cut costs in a way that traditional auction houses are unable to follow.

However, eBay went beyond simply producing a disruptive innovation based on the value chain and deployed a second disruptive innovation based on customer value. As all of the information about the goods is now feely available, auctions can involve buyers from anywhere in the world and take place over a period of several days: a process that would not be possible if all the buyers needed to be in the same place at the same time. This, together with various mechanisms for ensuring fair dealing, has made auctions on eBay an attractive proposition for customers who would never use a traditional auction house.

eBay provides a useful example to illustrate how a breakthrough strategy combines innovations that change both the customer value proposition and the costs incurred in a company's value chain. However, for the purposes of this paper, we will simply define a breakthrough strategy as the successful introduction of a radical change in the way a business operates that involves a new value proposition for the customer, a transformation of the value chain; in doing so created an entirely new way of doing business. Success, in this context, is defined simply in terms of the company's ability to outperform its competitors significantly.

3. PRODUCT ARCHITECTURE AND BREAKTHROUGH STRATEGIES

Most breakthrough strategies come from new companies that are unencumbered by tradition and an established way of doing things or from companies operating in new markets such as hi-tech companies. Charitou and Markides (2003), highlight a number of barriers to strategic innovation for established enterprises. Although examples of innovations that lead to strategic breakthroughs are less frequent, it is possible to find examples of how changes in product design can trigger change in even the most long-standing industry. Hagel, Brown, & Davison (2008), describe how McLean's use of standardized shipping containers, together with a freely available and innovative design for a fitting and locking mechanism for those containers, transformed an industry that had changed little for centuries. Containers now carry approximately 90% of non-bulk cargo and have had an influence well beyond the restructuring of the shipping and docking business, and have been argued by some (Levinson, 2006) to be one of the major factors in the globalization of world trade.

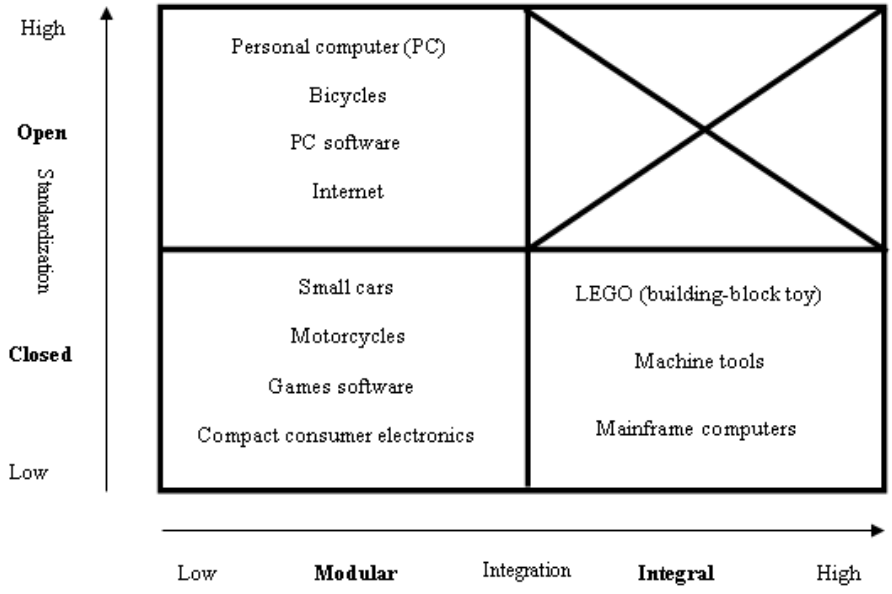
Although strategic breakthroughs in long established industries may not be as frequent, many of the same principles that are found in new hi-tech industries can be found in cases

where breakthrough strategies emerge in more well-established sectors. Friedel (2007), emphasizes the importance of questioning existing assumptions, challenging mental models and connecting seemingly unrelated ideas to create engineering breakthroughs. In an attempt to describe the process by which companies achieve such breakthroughs Fraser (2007) explains that, by applying the broad principles of design to business strategy, organizations will be able to 'stay ahead of the curve'.

She describes this process as consisting of three gears. The first gear is being able to reframe the business through the eyes of the customer. This is more than a simple marketing exercise as it involves a profound understanding of the customer's needs and the ways in which they relate to the product. The second gear is concept visualization, where an abstract understanding of users' needs becomes a concrete expression of what the product should be and how it will serve the customer's needs. Finally, the third gear, what Fraser calls strategic business design, involves applying abductive reasoning; making the conceptual leap to think, 'If feature X were available, then all of our ideas about what we want to do with this product would follow naturally'.

Others use the concept of product architecture to explore the links between strategy and design. Ulrich (1995) provides one of the widely accepted definitions of product architecture as the scheme by which the function of a product is allocated to physical components and through which the components interact. Ulrich identified five areas where product architecture had the potential to make a strategic impact (1) product change (2) product variety (3) component standardization (4) product performance and (5) product development management. In Japan, Takahiro Fujimoto has developed the link between product design and business strategy further and conceives of the entire manufacturing process, which he terms monozukuri, in terms of the creation and control of value carrying design information (Fujimoto, 2007).

Table 1. Fujimoto's taxonomy of product architecture



Fujimoto defines product architecture in terms of an approach that links the functional and structural design of a product. He divides product architecture along two dimensions: modular-integral and open-closed. The modular-integral dimension refers to the level of integration of the components in a product. Products with a high degree of component integration have many-to-many links between their components, meaning that the product has to be produced as a single integrated unit. A low level of component integration means that components have a simple one-to-one correspondence and can be treated as discrete modules. The open-closed dimension refers to the level of standardization. An open architecture implies the existence of industry wide standards for components; a closed architecture means that standardization only exists within the boundaries of a single firm or group.

By combining these two dimensions, Fujimoto identifies three possible forms of product architecture, open-modular, closed-modular and closed-integral. According to Fujimoto, the fourth category, open-integral, is a logical contradiction and a practical impossibility.

Fujimoto's classification of product architecture provides us with a useful and powerful way to think about the links between the design of products and the strategic positioning of a company. For example, using Fujimoto's ideas, the often-repeated story of IBM (Baldwin & Clark, 1997) can be recast in terms of a story about the links between the evolution of product architecture and a businesses' overall strategy.

Early computers were 'ac hoc' machines: quite literally built for a particular purpose. Thus, in 1957, in response to the demand for machines that could perform repetitive calculations, IBM introduced the IBM 704 EDPM (Electronic Data Processing Machine), a machine with its own dedicated operating system, peripherals and programming language. These machines clearly fit in the closed-integral cell of Fujimoto's model.

By the 1960s, in response to the continuing growth in demand from business, IBM moved production into the closed-modular cell of Fujimoto's model and started to produce machines that had some degree of compatibility with other IBM machines. Consequently, in 1962, IBM launched its famous System/360 range that consisted of a family of six different types of computer capable of sharing up to 40 different peripherals.

By the 1980s, the market had changed again. In the late 1970s and early 1980s, Apple was the leader in the newly emerging desktop computer market. IBM, who dominated the mainframe market, saw the threat to its position and launched its own desktop PC. In order to cut costs and development time IBM outsourced heavily. Distribution was given over to retailers, the processor was sourced directly from Intel and the operating system was bought on licence from a start-up company called Microsoft. By adopting this strategy, IBM effectively moved the production of the PC into the third open-modular cell of Fujimoto's model.

This story both illustrates the way in which a product's architecture can change and evolve over time and some of the strategic risks that evolution can involve (Henderson & Clark, 1990). IBM's strategy successfully saw off the threat from Apple, but in doing so, they eventually lost control of the desktop market. Intel sold chips to other manufacturers who produced 'IBM Clones'. The retailers who sold IBM PCs also sold 'IBM Clones', which were often cheaper. Microsoft, who had become rich through the licensing deal they had with IBM, now became its direct competitor in the software market. IBM did attempt to keep the PC market in the closed-modular cell of Fujimoto's model with the introduction of its proprietary PS/2 architecture in 1987, but as this architecture did not support the windows interface that

was being promoted by Microsoft, IBM eventually lost the battle for the lucrative desktop market.

4. ARCHITECTURAL EVOLUTION IN THE AUTOMOBILE INDUSTRY

Although there is no single pattern to architectural evolution, according to Baldwin and Clark (1997), the general trend is a movement from closed-integral to open-modular architectures. Baldwin and Clark claim that this trajectory can be seen not only in hi-tech industries, but also in the production of complex mechanical products such as automobiles; they give the example of Mercedes-Benz using a driver's cockpit that has been prebuilt as a module by a subsidiary of General Motors as an illustration of this trend.

In Fujimoto's terms, it can be argued that the automobile industry has experienced two main transitions: the first from open modular to closed integral product architecture, and the second from closed integral to closed modular. In the 19th century, production was a process carried out by craftsmen. Building cars was a matter of assembling a car from modified or adapted standard parts - mostly those from horse drawn vehicles – available on the open market: essentially an open modular product architecture. The invention of the internal combustion engine and the introduction of steel and aluminium sheets at the beginning of the twentieth century saw the beginning of volume production and a move towards a closed integral product architecture.

According to Langlois (2002), the 1930s marked the start of true mass production and the closed integral system. Two features can be identified: a high level of vertical integration in terms of production and a highly centralized design facility. This model remained dominant until the 1990s when, driven by competitive pressures, a number of leading European manufacturers began to move to a closed-modular type production, e.g. platform sharing between Citroën and Peugeot in the PSA group, or Volkswagen, Audi, Skoda and Seat in the Volkswagen group. However, this modularity has remained at the company, rather than the industrial level; consequently, the change from closed to open product architectures that we can seen in the PC industry is not present in the US or European automobile industry.

In China however, carmakers and their suppliers have begun to move towards a more open, modular form of production based on what is termed quasi-open modular product architecture. Fujimoto describes this development in the following way:

> *"... imitation-turned-versatile parts are being gathered and assembled by numerous companies and this is different from a full-fledged open architecture based on a carefully worked-out plan as seen in various digital products made by American companies"* (Fujimoto, 2002, p 35)

During China's industrialization, best selling foreign products were copied through either licensing or reverse engineering. Major components from foreign automobiles, such as engines and chassis, have, through repetitive remodelling, become de-facto generic components that can be used by indigenous manufacturers. This, in turn, lowers the entry barriers for both assemblers and component suppliers. By mixing-and-matching remodelled components from existing automobiles, Chinese manufacturers are able to produce

completely new automobiles more quickly and at a much lower price than their foreign counterparts are able to achieve.

Although this approach is a radical departure from Western practices, it remains only a quasi-open modular architecture as the modularity of the remodelled components has not yet reached the industry level.

5. CASE STUDY – THE GEELY AUTOMOBILE CO. LTD

5.1. Method

The methodology used to produce this case study was an in-depth, longitudinal case history (Yin, 2003). The study was undertaken over a period of five years and was divided into three stages. The analysis was based on a dynamic model consisting of two micro-economic factors (Chinese and foreign firms), one meso-economic factor (the industry life cycle) and two institutional factors (the Chinese government and the WTO) (Wang, 2002).

The first stage was a preliminary field study that took place over a period of a year in 2002. Although Geely was at an early stage of its development at this time (sales were only 47.8 thousand in 2002) this study provides the basis for tracing the evolution of the company and the quasi-open modular architectures in the following years.

The second stage was an in-depth field investigation conducted between January and April 2006 when Geely's growth was more confirmed. This focused on Geely's product architecture and its relationship with suppliers; it consisted of telephone interviews followed by on-site meetings and company visits. The vice general manager, the plant director and the purchasing manager of Zhejiang Geely Automobile Co. Ltd. (one of Geely's most important assembly plants) were also interviewed.

The final stage of research involved updating and reworking of the original material and additional interviews. The vice president of the Geely Holding Group in Shanghai was interviewed in March 2007 to gain further insights into issues related to the competitive strategy and this was followed by a series of visits and interviews at Geely in May 2007. The interviewees were selected to ensure a number of differing perspectives were included. The majority of interviewees were middle or senior managers who had at least fifteen years experience in the automobile field. This afforded a broader understanding beyond the single firm level.

The full details of the case study, its analysis and its methodology have been published elsewhere (Wang, 2008).

5.2. Case Study and Analysis

The analysis of the case study that follows provides a concrete illustration of how the quasi-open modular architecture developed in China, how it works in practice and how it became a breakthrough strategy for the Chinese automobile industry. In addition, it also illustrates some of the unique social, economic and political features that contributed to the emergence of this particular form of product architecture.

5.2.1. The Background of the Geely Group

Behind each successful company is a great entrepreneur or professional manager. Mr. Li Shufu, a peasant turned entrepreneur, is the founder of the Geely Group. Born into a farmer's family, Li started business with his 3 brothers and 2,000 Yuan ($244) when he was just twenty. Seventeen years later, Li Shufu had become China's 49th richest man; according to Forbes magazine his private assets now amount to US$110 million. Three main stages can be identified in Geely's development. From the manufacture of simple refrigerator components, Li masterminded the company's entry, first into the motorcycle industry and then took up the challenge of the automobile industry.

Li made his debut manufacturing components for refrigerators and evaporators in 1984. When China initiated its economic reform and opened up to the outside world, internal demand exploded. Following a brief period where products were imported, hundreds of production lines for refrigerators were set up by domestic firms. The demand for refrigerators brought Li's family into the business and they built a factory in their hometown, Taizhou city, Zhejiang Province. However, the over-heating of the economy in the late 1980s led to the intervention of the government, which gave the right to produce refrigerators and related components to a limited number of designated factories. Without a manufacturing licence, Li was forced to close his plant.

At the beginning of the 1990s, the motorcycle industry was booming in China. To enter this business, Li had to overcome not only the technology barrier, but also deal with institutional regulations. During this period, the production licence for motorcycles, which was issued by the Ministry of Machine Building Industry, was reserved for state-owned enterprises. Li circumvented this problem by bailing out a nearly bankrupt state-owned motorcycle factory in Hangzhou, Zhejiang Province. The annual production of motorcycles soon reached 600 thousand units, some of which were exported to counties such as the United States, Germany and Italy. In a short time, Geely had become one of the leading motorcycle manufacturers in China.

It is perhaps not surprising that the next big move for the company was to expand its business into the automobile sector. Refrigerators, motorcycles and automobiles were the three products most affected by the rise in living standards and purchasing power that followed the economic reforms of the 1980s (Wang, 2008). The Chinese middle class, who buy these goods, are highly price sensitive but also very concerned about the appearance of the product, which is an outward expression of their social status. Geely was able to identify precisely what the consumer wanted but, in addition, was able to develop a product architecture that allowed it to produce a low-price / low-cost product that was tailored to meet specific local needs.

Compared to their experience of other industries, the entry barriers to the automobile industry were high. Mastery of complex technologies and heavy capital investment are prerequisites in the automobile manufacturing industry. In addition, the institutional entry barriers in China are higher than in other sectors. The industrial policy and regulation barriers imposed by central government are significant. When Geely planned to access the automobile industry in the late 1990s, there were around 120 automobile manufacturers. The central government instigated measures to consolidate the industry and promote a small number of state-owned national leaders. The approval process for new projects was severe and Geely possessed little credibility as an automobile manufacturer due to its lack of technology, management and capital to launch such an activity.

Li was compelled to resort to unorthodox practices in order to surmount these barriers. In 1997, the company set up a joint venture with an ailing state-owned minivan plant in Deyang County of Sichuan Province, thereby gaining a license. However, Geely still could not produce its own model. In line with the regulations, each type of vehicle proposed by an automobile manufacturer had to be approved separately. Li approached various authorities lobbying for licences and finally, several days before China's accession to the WTO, the China State Economic and Trade Commission (SETC) approved several of Geely's models. They were listed under the less regulated 'bus category' despite the fact they were automobiles. Geely was officially registered as the first private automobile manufacturer in China in December 2001.

Despite such an inauspicious start, Geely became the ninth largest automobile manufacturer in China in less than ten years. Selling 230 thousand units in 2008, a year on year increase of 11.6%, they have succeeded in increasing their exports by 79.8%. In addition, they have expanded their production capacity to 500 thousand units and set up five new manufacturing sites. The company's success in creating a breakthrough strategy from such unpromising beginnings is based in part on its founder's deep understanding of Chinese markets and in part on the innovations that it has made in its product architecture.

5.2.2. The Development of a Quasi-Open Architecture at Geely

Initially, Li thought an automobile was simply a combination of capital, technology and human resources. The technology was mature and could be acquired either from the open market or through the recruitment of engineers. The first prototype was based on the combination of two vehicles: a Mercedes Benz and a Red-flag, a Chinese automobile produced by First Auto Works (FAW) based on Audi technology. Its body was constructed with glass fibre-reinforced plastic. Quality and safety tests proved that this combination was not suitable for mass production.

Li reworked his strategy, focusing on the imitation of a single vehicle, an approach that reduced the technology barrier for Geely and was the origin of quasi-open architecture pioneered by the company. As elsewhere, various components from best selling foreign automobiles were reverse engineered and copied, however Geely's approach differed in one important respect: the architecture of the copied product was progressively altered so that the high-level mixing-and-matching of components from different sources became possible.

The first stage in the development of Geely's quasi-open architecture came with their first production model in 1998. The *Haoqing* was based on the *Charade* produced by the state owned FAW Xiali, which was itself the result of technology transfer from Toyota's affiliate, Daihatsu. Initially, around 60% of components (including the engine and transmission) were purchased directly from FAW Xiali, with copied components accounting for another 10%. Consequently, around 70% of the components of the *Haoqing* were inter-changeable with that of the *Charade*.

Later, in the second stage of development, the mixing-and-matching of components was increased. The *Maple*, which entered production in 2002, was based on the combination of two foreign models already produced in China: the French *Citroën ZX* and the *Charade* (originally from Japan). The body and chassis of the *Maple* was based on the imitation and remodelling of *Citroën ZX*, while the engine was based on the remodelling of a Toyota engine. From this point of view, the *Maple* was more of an open-modular design than the *Haoqing*.

Combining components from automobiles designed with an integral or closed modular architecture (the *Citroën ZX* and *Charade*) to build an automobile with a quasi-open modular architecture (the *Maple*) was a major technical challenge for Geely. Architectural change requires a significantly higher level of technological and engineering capability than copying. The most recent models produced by Geely have reached a high level of modularity, going well beyond the closed modular model typical of leading western manufacturers. For example, the engine produced by Geely will fit into bodies derived from different models produced by different manufacturers, while the automobiles produced by Geely can accommodate different engines bought in from the open market. In short, the interface between the engine and the rest of the automobile has been designed to allow the manufacturer to mix-and-match these components in a flexible and efficient way.

A senior manager at Geely explains,

> *"During the design period, enough space has been reserved for an engine. We've tried to assemble different engines on the same car, and all of them work without the need to change the rest of the car's architecture".*

This architectural innovation, both at the level of the engine and that of the whole automobile, has helped Geely to reduce its costs significantly. For example, Geely's new car, based on the TX4 London taxi, can be equipped with Mitsubishi gasoline engine bought on the open market. Similarly, Geely's MR4790Q engine can be produced at one third of the price of a Toyota engine because the components of Toyota's engine have become "imitation-turned-versatile" parts that can be produced at low costs and in large volumes. In terms of total cost, Geely's plant manager observed,

> *"If our competitors are selling their vehicles (of the same category) at prices as low as ours, they are losing money, whereas we still make profit."*

The final element in Geely's breakthrough is that it has enabled the creation of innovative inter-firm relationships that support its overall strategy. As with the example of McLean's containers, an innovation that takes place in one area has begun to have an impact far beyond its original field.

A high percentage of a vehicle's components (around 70%), including parts of the engine, are outsourced; consequently, Geely and its suppliers need to work very closely together. Geely strives to lower the price but must also maintain an acceptable level of quality to meet the local market's needs. To achieve this goal it has built on its links with its suppliers from its motorcycle business who are experienced in high volume production at low costs. This category accounts for 50 percent of its total number of suppliers. To ensure quality is maintained, the suppliers of big companies such as Volkswagen, Toyota, PSA, Nissan and General Motors are also integrated into the sourcing system. Having Geely as the customer helps those suppliers realize economies of scale because of the higher production volume. Thus, the architectural innovation that has taken place at Geely, is now contributing to a wider change at the industrial level.

6. CONCLUSION

Developments such as the quasi-open architecture found in Chinese automobile manufacturing seem to have the potential to produce automobiles of comparable quality to those of the established automobile manufacturers, but at a significantly lower cost. Although this phenomenon is still at the early stage of development, there are strong indications that it has the potential to have a significant impact on automobile production worldwide. In this concluding section, we will briefly review the strategic potential of this development and examine some of the reasons why it has emerged where it did, when it did.

6.1. The Strategic Potential of Product Architecture

Attaining low cost production is a perennial challenge for most manufacturers. The current incremental approach towards cost reduction using existing (closed integral or closed modular) product architectures, which predominates in the western automobile industry, seems to be reaching its limits; only a radical architectural change in product design will allow a company to lower its costs so significantly that its competitors will find the move hard to follow. In just a single decade, through its innovative use of product architecture, Geely has moved from having no experience of automobile manufacturing to being the ninth largest automobile manufacturer in China at a time when its western competitors are cutting back.

Geely has announced a sales growth of 25% and no job cuts despite the financial crisis and a global economic downturn. Leading automobile manufacturers in other parts of the world are confronting multiple challenges to their position; so far, the response seems to have been to continue to adhere to closed product architectures. However, technological advances such as greater fuel efficiency or the development of technically complex hybrid or other forms of 'green cars' have failed to stimulated sales in mature markets. Mainstream western manufacturers may have the edge on new technology, but this alone seems unlikely to give them the strategic breakthrough they need.

The current automobile giants and others need to be fully aware of the strategic potential of innovations in product architecture, both as a potential driver of breakthrough strategy and as a threat to the current position. Manufacturers based in the mature markets of the US and Europe ignore the lessons of low-cost production through innovations in product architecture that are beginning to emerge from China at their peril. The so-called 'low cost cars' like Logan of Renault are still far beyond the purchasing power of mass consumers in developing countries. Abandoning the bottom of the pyramid, as the market in developing countries is sometimes called, and ignoring the innovations driven by product architecture could prove to be a double mistake.

6.2. The Role of the Emerging Markets in China

Although Geely's progress has been dramatic, it is by no means an exceptional case in China's automobile industry. Other local automobile manufacturers, including Chery, BYD

and Great Wall are making similar progress using similar methods. We estimate that automobiles featuring quasi-open architectures now represent around 30% of total production in China. In addition to the manufacturers, developments among component suppliers are reinforcing the move towards quasi-open architectures. For example, Mitsubishi is selling its engines to at least 21 different automobile manufacturers in China and Delphi's Engine Management System has become modular so that it can be used with any Mitsubishi engine in order to increase its sales. In short, the Chinese market has become the crucible from which new product architectures for automobiles have begun to emerge: local consumers, manufacturers and leading component suppliers are all contributing to the expansion of the quasi-open architectural paradigm. There are several possible explanations for this.

At the level of the individual firm, Chinese companies are more cost-oriented than product performance-oriented. This strategy helps Chinese firms compete effectively with foreign companies in terms of market share in the low-end product segment. Consequently, modular architecture tends to be the preferred choice. At the industrial level, there is no single firm that has a high enough level of product technology that it can dominate the marketplace; thus, there is a division of labour throughout the value chain and the 'buy' rather the 'build' approach is the norm. From an institutional point of view, Chinese industrialization started in the early 1980s but accelerated during the 1990s. Without a solid industrial base, path-dependency is significantly lower than that in developed countries. Chinese firms are not locked into a particular product architecture or organizational pattern. Facing technology constraints, imitation of a small number of popular models produced by foreign competitors has become the most viable solution.

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