From Adaptation to Complete Vehicle Design: a case study on product development capabilities of multinational assemblers in Brazil

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Abstract

The paper is concerned with the technological activities accomplished in multinational subsidiaries of carmakers in Brazil, particularly with their involvement in product development (PD) and the related acquisition of technological capabilities. It has been found that carmakers have been following different PD strategies and present a variation of PD capabilities what justified the definition of a specific typology according to their levels of complexity. An in-depth case study has been carried out about the Meriva project (GM Brazil) that has been one of the most complex cases of PD performed by a Brazilian automotive unit ever. Amongst its findings, there has been a change on the quality, complexity and responsibility of the activities the Brazilian engineering has carried out, about to qualify some of the subsidiaries to play a major role on automotive global PD.

Keywords

Multinational corporations; Brazilian carmakers; Product development competencies; Technological capabilities.

1. Introduction

Not so long ago, the most common understanding of the role played by subsidiaries of multinational corporations (MNCs) in developing countries' technological learning was that it was very limited (Lall, 1992). The disseminated idea was that such subsidiaries were entirely dependent on parent company to develop and introduce technological product and process innovations. Thus their accumulation of technological capabilities was limited to efforts oriented towards minor product and process adaptation. Since the late 1990s, this argument has been softened, if not reviewed, as result of fresh empirical research on the consequences of globalisation (international integration of firm operations) for the prospects of technological capabilities and exports in the most industrialised developing countries. Research on the experiences of India (Reddy, 1997), Malaysia (Ariffin and Bell, 1999), Singapore (Amsden *et al*, 2001) and Brazil (Quadros *et al*, 2001; Costa and Queiroz, 2002; Ariffin and Figueiredo, 2003) suggests that the generalisation about a marginal contribution of MNCs´ to technological learning in such countries is misleading. Furthermore, the evidence indicates that MNCs' subsidiaries should not be treated as a monolithic group, since they vary in their technological strategies, efforts and consequent competencies (Franco and Quadros, 2003).

This paper seeks to contribute to the understanding of such diversity by discussing the technological activities accomplished in Brazil by MNCs subsidiaries of carmakers, particularly with their involvement in product development (PD) and the related acquisition of technological capability. Previous research (Quadros and Queiroz, 2001; Consoni and Quadros, 2003) revealed that vehicle assemblers located in Brazil reacted differently to the challenges the automotive industry underwent in the past decade, after trade liberalisation. Faced with growth in intra firm trade, acceleration in product

innovation and increasing integration into global manufacturing operations, some carmakers stepped up local product engineering and enhanced local design capabilities. Others, however, went the opposite way, in the hope of relying on PD activities further centralised in European, North American or Japanese R&D centres. At that time, these findings led us to reject the (still) common belief that globalisation would entail a general reduction in R&D activities of MNCs located in Brazil and the consequent re-centralisation in developed countries. Yet, important issues are still open to investigation. What roles vehicle assembly subsidiaries have played in building up local technological capabilities in Brazil? How complex are such activities? Are there innovative technological capabilities being accumulated as result of the involvement of subsidiaries with global PD?

This paper addresses these issues in the light of new findings produced by a research project on MNCs subsidiaries of vehicle assemblers, focus on car passenger segment, in Brazil (Consoni, 2004). The study is based on extensive, in-depth interviews carried out between 2002 and 2003 with product and process managers of all carmakers located in Brazil. After defined a specific typology according to the levels of complexity of PD activities developed by these carmakers, an in-depth case study was carried out about one of the most complex cases of PD performed by a Brazilian automotive unit ever. The case study includes interview with almost the entire team of technical managers who have been involved with GM do Brasil (GMB)'s most significant PD project, the compact monocab Meriva [1].

In addition to this introduction, the paper is organised in eight sections. Section 2 introduces the analytical framework utilised to examine and identify levels of technological capability. This framework provides the basis for describing the classification of PD competency types according to levels of complexity we have defined

in relation to Brazilian carmakers. Having outlined the conceptual framework, Section 3 presents a summary of the economic and institutional environment of the automobile industry in Brazil. The variation of levels of PD competencies within the group of carmakers is then organised into a classification, presented in Section 4. The following three sections summarize GMB's experience with the Meriva Project, in order to illustrate the evolution of PD competencies along the levels outlined in the classification discussed before. Section 5 examines how the acquisition of PD capabilities at GMB has followed a history of progressive and cumulative learning. As the stage with most complex competencies was reached by way of the implementation of the Meriva, the decision making process of such project and its integration into GM corporation's development activities are discussed in section 6. The capabilities learned from the Meriva experience are presented and discussed in detail in Section 7. The last section seeks to draw the most important conclusions learned from this empirical analysis for the debate on the role of MNCs in the development of technological capabilities in industrialised developing counties.

2. Conceptual framework about technological capability levels

This section outlines the analytical framework we have adopted for investigating the levels of complexity of PD capabilities in MNCs subsidiaries of carmakers in Brazil. Birkinshaw (1996) consider that capabilities, specially the "distinctive one" technological capability, are the real engine of subsidiary growth with potential to gain new responsibilities inside the corporation. Others (Reddy, 1997; Amsden *et al,* 2001) attribute to technological capability strong influence on attracting and upgrading innovative activities developed by MNCs foreign subsidiaries. Thus, technological capability, defined here as the stock of resources such as skills, knowledge and experiences, embodied in workers and in the

organisational system, will be analysed as one of the necessary conditions for firms to generate technical change in different levels and to promote improvement over time (Bell and Pavitt, 1995; Figueiredo, 2001; Costa and Queiroz, 2002).

According to Lall (1992), the concept of technological capabilities is associated with a cumulative aspect. Firms accumulate experience, aptitude and knowledge over time through a learning process that influences their future progression, allowing them to evolve from mere users of technology (that is, imitation of technology developed by extern agents) to promoting improvements and changes in technologies adopted and up to generating new technologies. In fact, although time is a fundamental element in such process, it is not an automatic process. So, the accumulation of effective technological capabilities depends on explicit and systematic efforts, which demand a distinct learning mechanism and a consistent long-term process to be achieved and embodied in individuals and on firms. Beside the technological learning mechanism, the consolidation of technological capability, especially in subsidiaries of MNCs, is dependent on the overall corporate strategies and on the pattern of subsidiary-parent linkages.

In fact, the findings of our study present evidence of significant heterogeneity in carmakers' trajectories in Brazil, in the sense that both the technological capability level and the subsidiary-parent cooperation pattern are distinct between firms. Thus, activities performed by subsidiaries with different autonomy levels and distinct levels of knowledge complexity emphasise this point. The challenge for this paper is then to elaborate a classification of PD capabilities according to levels of technological complexity.

In order to carry out this task, and based on the literature on technological capability building, this paper draws on Lall´s framework. The ranking proposed by Lall indicates that technological capabilities accumulation follows various stages, running from a fairly

basic level (basic technological capabilities) through intermediate levels (intermediate technological capabilities) up to more complex and advanced levels that enable the firm to promote innovative changes (advanced technological capabilities). Lall´s classification was later modified by Bell and Pavitt (1995) into a relatively fine disaggregated taxonomy, in order to capture the types and levels of technological capabilities and was further empirically adapted by Ariffin and Bell (1999) and Ariffin and Figueiredo (2003) to analyse technological capabilities in MNCs subsidiaries established in developing countries.

As far as this paper is concerned, a particular contribution deserves attention in Bell and Pavitt (1995)'s disaggregated framework. This is the distinction between two broad types of technological capabilities: Routine Production Capabilities, which are basic capabilities necessary to use and operate the existing technology; and Innovative Technological Capabilities, which comprise capabilities to generate and manage technical change. The distinction between different levels and types of capabilities, according to their complexity, is an important contribution of this taxonomy. Thus, a certain level of capability accumulation is identified when a company has achieved the ability to do a technological activity that it had not been able to do before. It's worth to mention that such disaggregated framework can only be applied in a given industrial sector after a detailed, empirical and in-depth analysis of the particularities of its technological capabilities.

The framework discussed above constitutes the analytical reference used to analyse and classify the levels and types of PD capabilities in Brazilian carmakers, which is the subject of the following sections.

3. The Brazilian context and the role of vehicle assembler subsidiaries

Benefiting from high protection, the Brazilian auto industry developed until the 1990s exclusively oriented to the internal market. During this period, the Brazilian automotive sector comprised only four passenger car assemblers (GMB, VW-Volkswagen, Ford and Fiat), besides other utility vehicle assemblers.

Although most vehicles produced in Brazil were adaptations of designs developed abroad and adapted to local market, there were some exceptions. The main significant case happened in 1980, when the Brazilian unit of VW designed the BX Family, which was the platform of the subcompact Gol and its derivatives (pick-up, station wagon and notch). Both the concept and design of that model were developed under the Brazilian engineering team responsibility. However, this kind of strategy intended to manufacture cars primarily for the local market; exports from Brazil were much less important than they are today and thus the local subsidiaries could do well with dated models and quite limited PD activities.

Major changes happened in the early 1990s, which account for a new phase in this automotive industry. These changes implied a significant redefinition of local product and technology strategies of assemblers in Brazil. Two elements had great influence on these changes, namely, trade liberalisation and government polices.

The process of trade liberalisation started in the early 1990s and showed that Brazilian assemblers were not prepared to face import competition. The sudden explosion in vehicle imports intensified domestic competition and turned evident the need to update products and improve productivity rates and quality standards in car manufacturing. In consequence, the investment made by assemblers in Brazil rose from US$ 5.4 billions, in the 1980s, to US$ 16.6 billions, in the 1990s. The largest share of such investment was made by carmakers already located in Brazil. New entrants accounted for the other share of

investment. Toyota, Honda, Renault, PSA-Peugeot-Citroën, VW Audi and Daimler Benz inaugurated their first passenger car plants in Brazil, between 1997 and 2002.

Such investment effort aimed at, firstly, taking the opportunity to enlarge the consumer vehicle markets. The scale of the market is another factor that attracted investment flows into Brazil. The peak was observed in 1997 and again in 2004, when 2 million vehicles were manufactured.

As important as the market size factor may be, the impact of government policies focusing this sector, specifically the Automotive Regime, should not be underestimated as additional incentive in the process of attracting new vehicle assemblers to Brazil. Such Automotive Regime, which was implemented between 1996 and 2000, introduced a series of incentives for exports and for the building of new plants in Brazil. Thus, carmakers PD strategies have been greatly influenced by the new phase in the domestic automotive market characterised by fiercer competition as well as a deep restructuring process. Indeed, the number of new car platforms launched and manufactured in Brazil in the 1990s (total of 22) was more than three times the launchings observed in the 1980s. Overall, the new product strategies have replaced the launching of vehicles based on or derived from obsolete platforms, which has prevailed for decades.

4. Product development competencies in carmakers subsidiaries

An important dimension of globalisation in the automobile industry is that all major competitors have organised product portfolios and supply chains around the concept of global platform and modules/systems of components [2]. Such practices have produced a leap in the possibility of sharing auto-parts between different models, therefore increasing economies of scale, a critical aspect of competition in the industry. However, the wide dissemination of the principle of global platforms has not implied that all carmakers have

adopted the same product strategy, the same organisation of PD or even the same concept of platform (Muffato, 1999). In fact, this section reveals how different product and PD strategies pursued by carmakers located in Brazil can be and how different their options for organising PD have been, between centralisation (in headquarters, European or North American subsidiaries) and decentralisation of PD (with greater autonomy for the Brazilian subsidiary).

In general, product-related technological activities developed by automakers in Brazil have been concentrated mainly on platform adaptations to local conditions (tropicalization) and, to a lessen extent, on the development of local models, or derivatives vehicles, from global platform to suit local demand requirements. Yet, at the level of the individual firm, trajectories have varied considerably and evolved sometimes in a rather hesitating way.

On one hand, there are cases of assemblers which have relied primarily on technological activities developed abroad, thus following a completely centralised product strategy. This has been the case of the carmakers installed in Brazil in the late 1990s (Renault, PSA, Toyota, Honda and Daimler Chrysler). However, it is important to mention that their scale of operations in Brazil is small (compared to the major players), given their relatively incipient experience and activity in the country. Thus, there is no evidence that these assemblers will follow a more decentralised product strategy in the near future.

On the other hand, the recent experience of some the major assembler subsidiaries (GM, VW, Fiat, Ford), and their accumulated design competencies, suggest the possibility that they are becoming partners to their headquarters in global products development. Due to the large specialisation of Brazilian market in consume of subcompact car, these assemblers have developed competence in the design of small and efficient engines (up to 1.000cc.). The development of suspension modules is another competence in some of these

carmakers. As a matter of fact, GM and VW are the most significant cases. They have adopted decentralised product strategies, although following the global platform concept. Moreover, they have experienced a growth in extension and density in their PD activities and have been strongly engaged in designing regional derivatives from global platforms. Such strategy has implied an enlargement of the Brazilian engineering capabilities, increasing technical staff and improving local technological facilities. In fact, GM and VW not only have historically accounted for the largest investment in laboratories in Brazil, but also employ more PD engineers. Thus, although Fiat has had a modest technological facility, it has recently initiated an investment program to expand laboratories and to build a design centre, the first outside Italian headquarter. Ford has presented an opposite trajectory, at least until recently. In spite of being an assembler established for long in Brazil, Ford has chosen to further centralise its technological activities in its European and North American R&D centres. As such strategy has not worked well, leaving Ford with a poor supply of compact cars and in a fragile position in the Brazilian market, recently the company has decided to re-invest in strengthening the engineering and designing capabilities in Brazil.

The differences commented above in the localisation of PD activities have had significant implications in carmakers' accumulation of technological capabilities for PD in Brazil. Indeed, based on the analytical framework (Section 2), which uses a disaggregated taxonomy to examine types and levels of technological capabilities, our empirical research has revealed that: first, such PD capabilities could be organised in five stages with crescent levels of complexity, as shown in Figure 1. Second, individual carmakers have reached distinct levels of complexity, from Routine to Innovative Capabilities.

Insert Figure 1 here

The classification presented in Figure 1 involves five levels of technological capability (according to complexity), which can be grouped in three types of capabilities. First, at the bottom of the figure, the Nationalisation levels corresponds to the Basic Capabilities necessary to operate in the country, which are accumulated through a learning-by-doing mechanism, following Bell's definition (Bell, 1984). That simplest level of PD capability is related to the nationalisation of parts and components. This is a routine skill, which any carmaker operating in the country must develop and refers to being able to searching, selecting and contracting local suppliers to produce parts and components in order to reduce dependency on imports. Engineering competencies here have to do with evaluating suppliers and keeping links between such suppliers and manufactures abroad. Most of the new comers, which maintain small operations in Brazil, have not gone beyond this basic level, since even their tropicalization activities have been carried out in their headquarters.

The second type is Incremental Innovative Capabilities to improve, change or create products, which involve more complex activities and demands more sophisticated engineering knowledge. However, such capability type comprehends three levels of intermediate PD capabilities -Tropicalization, Partial Derivative Projects and Complete Derivative Projects- which are characterised by cumulative and more dynamic and complex technological knowledge.

The second level -Tropicalization- refers to the capability for adapting existing platforms and derivative models to specific requirements of local market or of local production. This comprehends a wide range of issues, from the use of alternative fuels (ethanol) or variations of gasoline composition, to adaptation of suspension to bad road conditions and to the search of cheaper or more adequate materials. Particularities in consumer taste, which may affect design, are also included here. All incumbent carmakers have developed

a strong basis in such competencies, which has given them considerable competitive advantage over new comers.

The following level -Partial Derivative Projects- corresponds to more recently developed capabilities, mostly after trade liberalisation in the 90`s. It refers to the technological competencies necessary in order to design partial derivatives from global platforms and global models. The typical example is the development of notch (sedan), wagon and pick-up versions from hatch platforms, as recently GMB has done from the Corsa platform (Montana Pick-up) and VW from Polo platform (Polo Sedan). Although with closely technical partnership with the parent's PD Centre in Italy, Fiat Brazil has done something similar with the Palio platform (the Siena), as well as Ford from Fiesta platform (Fiesta Sedan). However, both Fiat and Ford have not gone beyond this level. Ford mainly due to its inconsistent trajectory in the past decade although it has made important progresses in this area.

The fourth and most complex level found refer to the capability for designing and engineering Complete Derivative Platforms. As this level is further explained in section 5, it suffices to say here that it refers to the competencies required for the development of entirely new models from existing platforms, sometimes requiring extensive re-engineering of platform dimensions and new base knowledge for new product design. Only GMB and VW have reached this level, with the development of the Meriva (GMB) and the Fox (VW). Moreover, differently from the situation of partial derivatives, typically aimed at regional markets, such completely new derivatives are global products, developed in Brazil not only for South American but also for European markets.

We emphasise that, although the PD competencies typology (Figure 1) seems to be linear, it does not imply that the accumulation and upgrading of technological capabilities from

Brazilian carmakers has followed a linear and unique trajectory, without difficulties or problems. As mentioned before, the recent history of Ford Brazil shows the opposite of a linear trajectory. Thus, the role to be played by the subsidiary in corporation global strategies has important impacts on both the levels of technological capabilities attained and on new world product mandates gained.

It is exactly subsidiary mandate restriction the reason why the third type of technological capability, Advanced Innovative Capabilities, has not been developed yet, in Brazilian carmakers. This refers to the most complex technological level on the top of our typology –Platform- and would imply the design of a complete platform and its derivative versions by Brazilian subsidiary. The reason for this is more related with MNCs' global strategies and the role assigned to Brazilian subsidiaries in such strategies, than with absence of technological capabilities for designing entirely new products. As we could notice, some carmakers have already consolidated the base knowledge for designing a complete platform in Brazil, particularly for the compact and low cost car segment, but do not have a world mandate for management it, following the Birkinshaw's definition [3]. The description of GMB' Meriva development contributes to understanding that point.

5. Evolution of the product development strategy at GMB

Even though GM started assembling CKD units in Brazil in the 20s, under the brand Chevrolet, it was only in 1968 that GMB began manufacturing cars locally. GMB produces cars and SUVs (sport utility vehicles) aiming mainly at South American markets, but in recent years Mexico and China have become the major destinations of exports. GM´s European division Opel is the major source of product/process technology and the owner of car platforms manufactured by GMB. Yet, as far as truck and large pick-up models are concerned, GM's headquarter in US is the source of project.

In spite of such dependence on technology transfer from abroad, GMB's automotive engineering unit enjoys considerable autonomy to introduce changes in the original platforms, so that the derived products can be suited to specific market requirements. Gradually, GMB's engineering team has significantly upgraded its technological capability in PD, moving from basic vehicle adaptation to more advanced levels of PD competencies. Such evolution was accelerated when tougher competition in the internal market, stemming from trade liberalisation and the coming of new entrants, led Brazilian incumbent assemblers to upgrade products, shorten product life cycles and reduce the gap between local and global products. By the late 90s, GMB had accumulated competencies up to level three of the typology discussed before: nationalisation, tropicalization and partial derivative designing. Technological competencies for designing partial derivatives were developed and acquired mainly by means of accomplishing the projects of regional derivatives from the global vehicles Corsa Generation II and III (notch, station wagon and pick-up) and Astra (notch).

The availability of PD capabilities and vast technical infrastructure, with a complete Proving Ground, as well the significant rise in sales of the so-called "popular" cars (1.0 compact cars) in the Brazilian domestic market created the requisites for GM to decide investing in the development of the Blue Macaw Project. The project gave birth to the Celta, a sub-compact car derived from the Corsa Generation II, with substantial modifications and re-design in order to suit a consumer who, in spite of lower income compared to the European consumer, was still keen to purchase a brand new, subcompact car. The Celta project entailed two major advances for the local engineering unit. First, GMB's engineering team has had a major participation during all stages of development. As the Celta was specifically planned and designed for the Brazilian market (and other

developing country markets) and as GMB has co-ordinated all the development process, such experience represented an important step forward in terms of acquiring the engineering and managerial capabilities, from concept to launching. Second, the Celta project involved significant innovations in the car manufacturing process, particularly in terms of the organisation of the supply-chain, with the introduction of the "industrial condominium" model of clustering suppliers around the assembler plant. This concept is defined as a compact and modular plant at which the assembly line is segmented into modules, which are operated by suppliers [4]. Suppliers have been installed inside GMB plant at Gravataí (a green field site located in the town of Gravataí, in the southern state of Rio Grande do Sul) and have held responsibility for the entire development, delivery and assembly of modules or complete systems. Such responsibilities comprise the employment of direct workers, the development of tools and equipment and the control of the assembly logistic. Furthermore, suppliers have assumed the financial burden of the investment in their own piece of the plant, in order to assembly customised modules and deliver them just-in-time to GMB's final assembly line.

The previous experiences have assured GMB a significant role in PD activities inside the corporation. This has been reinforced in the process of conceptualising, developing and launching, in 2002, the monocab Meriva, which corresponds to a Complete Derivative Project, classified at the highest PD competencies level, according to our typology. Opel's Technical Development Centre in Rüsselsheim, Germany, and GMB's Design and Engineering Centre in São Paulo carried out the Meriva project jointly.

However, that development has been considered a new phase in terms of PD mandate, not only for GMB but also in the context of the Brazilian auto industry. On one hand, it has been the first case ever in Brazil of a global PD project proposed by the Brazilian

subsidiary, co-ordinated from the subsidiary and later incorporated into the global corporation's product portfolio. The monocab Meriva has been launched in Brazil in 2002 and in Europe in 2003; in Europe it has been manufactured at the Saragoza plant. The experience has inverted the prevailing direction of the knowledge flow between GMB and Opel. It represented a pioneering decision and a great responsibility for the Brazilian engineering team. Even thought GMB has worked closely integrated with and supervised by Opel in this project, having received from the latter the necessary technical support whenever this was required, the Brazilian engineering was effectively in charge of project co-ordination and carried out the largest part of the engineering tasks. On the other hand, it has been the first PD project located in the country, which has involved thorough re-engineering of the dimensions of the original platform (Corsa). It was modified to be integrated to the rear part of the Astra platform, resulting in what the interviewees at GMB call a "hybrid" platform.

The next section goes further into understanding the meaning and implications of the development of such hybridism, by examining the evolution of the decision-making process of the project.

6. From partial to complete derivative design: evidences from the Meriva project

In the late 90s, the monocab Zafira, based on the Astra platform was launched in the European market; at that time, GM Corporation's plans were for GMB to assemble and launch the vehicle in Brazil, which eventually happened. Yet, the first GMB idea was to develop a new five-seat monocab, which should be smaller and less expensive than the seven-seat Zafira. The latter was then considered too sophisticated and expensive for the South American market. After the experience with Zafira in Europe and Brazil, Opel came to learn that there was indeed a market opportunity for a smaller and cheaper compact

monocab in both markets, which led to the decision of developing such vehicle, in the year 2000.

However, the Opel engineering unit was then fully busy and had no capacity to take on a new vehicle program. The final decision regarding the allocation of the small monocab project led to a partnership between both GM subsidiaries: GMB was given the technical responsibility for the execution and co-ordination of this project and Opel was given the task to supply the necessary technical assistance and support. In the words of the informants, GMB "was contracted" by Opel to be the mentor of this project and responsible for its execution, not only for the Brazilian market but also for the European market.

The first important technological decision to be tackled by the new partnership was the choice of platform on which the new vehicle was to be based. At the time, Opel suggested shortening the Astra platform. GMB replied by suggesting the use of the Corsa Generation III platform as the major base (for front suspension and under floor) complemented with the back suspension of the Astra platform. The latter solution was economically superior (cost effective), as the Corsa is a compact platform, thus less expensive than the medium sized Astra platform. The integration of the Corsa platform to the Astra platform back suspension added an ingenious solution to the technical requirements of the project: the monocab's back suspension needed to be stronger than the Corsa's, in order to support a bigger load capacity and larger internal space.

This particular solution highlights a more general and significant engineering competence, that is, the capability to design low cost solutions. According to our informants, not only at GMB but also at other assemblers, Brazilian automotive engineering is increasingly recognised for its capability to provide cost effective solutions (low cost, reliable

performance). Cost is critical in developing countries, in which consumers' low income levels often demands solutions, which can combine less expensive products without compromising the critical aspects of performance.

Even though the Meriva is considered a derivative vehicle, it is indeed a hybrid platform. Previous research pointed to the fact that carmakers have been adopting the concept of platform with different interpretations, degree of implementation and implications (Muffato, 1999). The Meriva platform is a clear illustration that the platform concept is still in evolution. Furthermore, this case shows that whilst derivative models originate from previously designed platform, the degree of project complexity may vary substantially between derivatives. In the Meriva project, the derivative has been an evolution from the original platform, insofar as it has implied a new product architecture. This particular characteristic stresses the difference between a complete derivative like the Meriva and other partial derivatives, which not only GMB but also other subsidiaries of carmakers have been developing in Brazil, as shown in section 4. In a narrow definition, a partial derivative is defined as using the same platform and the same front floor and under floor of the original model. The change is in the rear floor (but not in the rear suspension), to introduce pick-up and sedan features to hatchback models. The main difference is in the external appearance.

Another important aspect is the fact that partial derivatives generally present very high percentage of shared parts and components with the original platform (between 70% to 85%, at GMB) in relation to the original platform. The Meriva shares only 55 per cent of parts and components with the Corsa and Astra, being 2/3 of them shared with the Corsa and 1/3 with the Astra. Thus, considering the cost of parts and components, almost half of the Meriva corresponds to new value.

As seen before, the Meriva has meant an unprecedented chance for GMB to design a vehicle not only for the local market, but for the European market too. The project demanded extensive re-engineering in the base platform and significant product modification, at a level of complexity that GMB had never performed before. The following of this article focuses on the PD competencies and innovative capabilities, which GMB has had to learn in order to complete the project successfully.

7. The upgrading in GMB's product development capabilities from the Meriva Project

The development of the Meriva took almost three years of activities and the partnership between GMB and Opel worked through every phase of the project. The Brazilian subsidiary was technically responsible for the program, and its engineering unit carried out approximately 70% of the hours of technical activities, according to interviewees. GMB's engineering directory co-ordinated all phases of vehicle development, comprising the performance of the following functions: concept definition, product planning, detailed product project, including prototyping and simulation, testing and product validation. GMB also performed most of the process engineering activities of the Meriva, including detailed process project, tool and dye designing and pilot manufacturing.

This section organises in two groups the evidence and analysis of the improvement brought about by the Meriva project to GMB's technological knowledge and PD competencies. Firstly, the organisation and managerial skills acquired in co-ordinating and implementing such project are addressed. Secondly, the accumulation of technological competencies involved in PD is explored. However, it is worth to emphasise that joint work with Opel during the entire development project was an important learning mechanism for GMB and

contributed significantly to both strengthening the existing capabilities and to creating new PD capabilities.

7.1 Organisation competencies: the Design Centre experience and concurrent engineering

The large size of the Meriva project and GMB's responsibility of managing it within considerable restrictions in terms of cost and time led the subsidiary to allocate an exclusive development team for this project, named Design Centre. In this respect, the Meriva project has inaugurated a new experience, which has been later transferred to other GM units outside Brazil. The Design Centre was composed with a staff of 180 professionals, from all Product Engineering divisions. Such staff worked full time for 30 months exclusively on this project. However, the number of professionals who collaborated was larger, as staff from Support Areas was occasionally allocated in specific project phases.

The Design Centre, as an organisational form, produced significant benefits in terms of development performance, and helped the team keep focus on the project. Well-distributed responsibilities within the team, leadership and cohesion contributed to keeping strong level of integration. In this connection, the leader of the Design Centre, that is, the Meriva Project Manager, was given large autonomy and authority, as the heavyweight manager in the Japanese experience (Clark and Fujimoto, 1991). With the finalisation of the project, the Design Centre was dismantled and its professionals returned to GMB's vertical engineering structure. It is worth to note that, although there has been no alteration in the formal engineering organisation, the Design Centre technical and tacit experience has been disseminated within all engineering divisions. In this respect, the experience can be considered as an important learning mechanism, in line with one of the objectives of the project.

Another important practice was the adoption of concurrent engineering concepts and techniques. In addition to introducing process engineering earlier in the development project, these practices have increased GMB and Opel integration and made possible greater synergy between technical teams from both subsidiaries. Such integration has allowed GMB to be in closer contact with Opel's best practices and technical performance. Working closer with Opel has contributed to the improvement in GMB's technological competencies.

A further important practice to promote the integration between Opel and GMB was the allocation of resident professionals, that is, the exchange of staff between both units to follow the Meriva development. Opel kept many residents at GMB during that period. The number and qualification of residents varied according to the specific project phase. The purpose was not only to supervise the activities but also to exchange experiences and knowledge regarding vehicle requirements for the European market, which are substantially more restrict than the requirements for the South American markets, in aspects such as emission, noise, safety and recycling standards. Though to a lesser extent, also GMB kept residents in Germany in order to follow the activities and strengthen the contact between both units. Exchanging residents between units has been another important learning mechanism to facilitate efficient communication and knowledge transfer.

7.2 Technological competencies related to the process of product development

The original Meriva Master Timing Chart (MTC) is the starting point and reference for the analysis that follows. MTC is a framework used in the automobile industry to control, co-ordinate and supervise PD projects. It is a management tool, which specifies in detail all current functions, areas and activities involved in the project, specifying starting and

finishing dates of each activity. Based on the Meriva MTC and the PD phases defined by Clark and Fujimoto (1991), our research has produced evidence that GMB accumulated new PD competencies in: (1) Concept definition; (2) Planning; (3) Product Engineering; (4) Process Engineering and (5) Production. Even though these phases are presented here in a sequential order, technical activities and engineering areas overlapped along the project. Thus there was integration and interaction between areas and activities, which vaied in intensity depending on the development phase. Overall, in despite of some difficulties in the Project coordination process, the Meriva experience has led GMB to master all phases in PD. Some areas more intensively, others not so much, but in general there was an upgrading of technological capabilities in product design at GMB. The following emphasises four technological areas in which upgrading was more intensive.

(1) Competencies in concept creation and style definition

These competencies are related to product specification, considering product performance, market segment positioning, cost, appearance, and so on. In Brazil and Europe, the Meriva should be positioned behind the Zafira monocab in terms of cost and size, but should be similar in terms of performance and security. Such characteristics had to be considered before the concept validation. Demand interpretation by concept creators (style department); demand and style concepts translated into engineering descriptions; and interaction among stylists and engineers along project development made possible such development and allowed the preservation of the vehicle features defined during the concept phases. This level of complexity in concept definition, product specification as well as interaction between style and engineering had never been experienced at GMB before.

(2) Competence in defining new product architecture

Although the Meriva is not recognised as an entirely new platform, the project presented great complexity in terms of original dimension. This is due to the solution based on the integration of both the Astra and Corsa platforms for the Meriva monocab. Defined as a hybrid platform, the Meriva modified the internal and external dimensions of the basic Corsa platform. Besides, it was the first time that GMB defined and designed a completely new packing for a vehicle. In this respect, low cost solutions proposed by the engineering team were critical to keep the economic viability of the project.

(3) Competence in component procurement and selecting auto parts suppliers

GMB took on the responsibility for defining suppliers for both markets (Europe and Brazil). This involved definition and accomplishment of all co-design activities with suppliers and interaction with engineering services firms.

(4) Competence in building, testing and validating prototypes

GMB has been building, testing and validating prototypes for years since it started to design derivatives and to change parts of vehicle projects according to Brazilian market demands. Notwithstanding, three aspects differentiated the activities carried out in the Meriva project in relation to previous developments. First, it was the first time that GMB built and tested so many prototypes for another division. In fact, GMB assumed the responsibility to building and testing all the prototypes for Brazil and Europe, including the ones tested only in Europe due to either specific climatic condition (temperature) or specific facilities not available in Brazil (as wind tunnel tests). Second, due to the complexity of such activities, in connection with the European more rigid norms for pollution control and safety equipment (crash tests). Third, due to the number of prototypes built, tested and validated. For instance, the Celta, the most complex development GMB

had carried out so far, required 1/10 of the number of prototypes required in Meriva project.

The building and testing of physical engineering prototypes was accompanied by mathematical simulation tests. In GMB, the simulation area was created in 1995 and has evolved quickly. The Meriva Project was considered the great jump for the maturity of this activity. The amount of simulation tests had an important role in upgrading staff competencies and technical report. The speed and efficiency of the virtual prototypes plus the feed back into product engineering were some of the advantages of these activities in the Meriva project, improving design chances early in the engineering cycle. GMB received the "Boss" Kettering Award 2000 from GM Corporation in recognition for such competence. The award contemplated the software called Virtual Proving Ground, developed by GMB, which provides simulation of the dynamics and durability of the vehicle. Using physical prototypes, GMB spends 3 to 6 months to complete these tests; by the Virtual Proving Ground software, the same test takes from 2 to 3 minutes. It is important to mention that the Virtual Proving Ground was not developed as a demand of the Meriva. However its intense application on this project confirmed the efficiency of the software.

8. Conclusion

Based on empirical findings, this paper has pointed to a set of levels and types of capabilities and competencies on auto engineering in Brazil, which has led to the definition of a typology of PD competencies. The discussion of the Meriva development, which is almost at the top of our typology and represents one of the most complex cases of PD performed by the Brazilian auto engineering ever, pointed to a greater integration between home-based and carmakers subsidiaries in Brazil. Such integration goes beyond

manufacturing processes and evolved sometimes in a rather complex way, including the PD activities. From the Brazilian technological point of view, GMB has experienced a deepening in its PD activities that has implied an enlargement of the Brazilian engineering competencies, improving local technological facilities and increasing technical staff.

However, there is not enough evidence to conclude that Brazilian car assemblers will either follow a more decentralised product strategy in the near future or perform a distinctive role in global PD. It's worth to notice that more complex technological product activities conducted by carmakers in Brazil are determined not only by their internal technological competencies but also by headquarter-led global strategies.

Although the research reported here has not focused on policy measures, it seems to underline that government and industrial policy can play an important role in promoting and intensifying technological activities and R&D performed locally. This research indicated that some carmakers subsidiaries in Brazil (GMB for instance, but others too) are ready to become headquarter partners in global PD. The stock of knowledge has already been accumulated and there are capabilities to design a complete platform in Brazil, specifically in the compact and low cost segment for developing countries. Thus it is necessary to promote the automotive industry growth in Brazil in a different way. Not only looking for production capacity improvement but also focusing the technological aspects that can contribute to insert the Brazilian subsidiaries of vehicle assemblers in multinational corporations' R&D networking.

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References:

Amsden, A. et al (2001) Do foreign companies conduct R&D in developing countries? *Working Paper Series*. ADB Institute Tokyo, n. 14, march. 28p.

Ariffin, N. and Figueiredo, P. (2003) *Internacionalização de competências tecnológicas***.** Rio de Janeiro: Editora FGV. 172 p.

Ariffin, N. and Bell, M. (1999) Firms, politics and political economy: patterns of subsidiary-parent linkages and technological capability-building in electronics TNC subsidiaries in Malaysia. In: Jomo, K.S. *et al* (eds.) *Industrial Technology Development in Malaysia*. London and New York: Routledge. p.150-190.

Bell, M. (1984) Learning and accumulation of industrial technological capability in Developing Countries. In: FRANSMAN, Martin; KING, Kenneth (eds.). *Technological capacity in the Third Word*. London: Macmillan. pp. 187-209.

Bell, M.; Pavitt, K. (1995) The development of technological capabilities. In: *Trade, technology and international competitiveness*. UI Haque, I. Bell, M.; Dahlman, C.; Lall, S. and Pavitt, K. Washington, D.C., EUA, The World Bank. P.69-101;

Birkinshaw, J. (1996) How multinational subsidiary mandates are gained and lost. *Journal of International Business Studies*, v.27, n.3, pp. 467-494.

Clark, K. and Fujimoto, T. (1991) *Product development performance*. Boston: Harvard Business School Press. 400p.

Consoni, F. (2004) Da tropicalização ao projeto de veículos: um estudo das competências em desenvolvimento de produtos nas montadoras de automóveis no Brasil. PhD Thesis. Science and Technology Policy, IG/DPCT, UNICAMP, Campinas. 269p. Available at: http://libdigi.unicamp.br/document/?code=vtls000330594

Consoni, F. and Quadros, R. (2003) Between centralisation and decentralisation of product development competencies: recent trajectory changes in Brazilian subsidiaries of car assemblers. In: *Actes du Gerpisa*, Paris, 11-13 June, 15p.

Costa, I. and Queiroz, S. (2002) Foreign direct investment and technological capabilities in Brazilian industry, *Research Policy*, nº 31, pp.1431-1443.

Figueiredo, P. N. (2001) *Technological Learning and Competitive Performance*. Cheltenham, UK & Northampton, MA, USA: Edward Elgar Publishing Ltd;

Franco, E. and Quadros, R. (2003) Patterns of technological activities of transnational corporations affiliates in Brazil. *Research Evaluation*, v. 12, nº 2, August, p.117-129.

Lall, S. (1992) Technological Capabilities and Industrialisation. *World Development*, vol. 20 (2). p.165-86.

Muffato, M. (1999) Platform strategies in international new product development. *International Journal of Operations and Production Management*, v.19, n.5/6. p.449-459.

Reddy, P. (1997) New trends in globalisation of corporate R&D and implications for innovation capability in host countries: a survey from India. *World Development*, v. 25, n. 11. p.1821-1837.

Quadros, R, and Queiroz, S. (2001) The Implications of globalisation for the distribution of design competencies in the auto industry in Mercosur. In*: Actes du Gerpisa*, Paris, Dec., vol. 32. p.35-45.

Quadros, R. et al (2001) Technological innovation in Brazilian industry: an assessment based on the São Paulo innovation survey, *Technological Forecasting and Social Change*, nº 67, pp. 203-219.

Notes:

1. The research focuses only the car passenger assemblers (carmakers) in Brasil; truck, bus and utility vehicle assemblers have not been investigated. Firms investigated included the major players (VW, Fiat,

Ford and GM), and the entrants of the 90s (Renault, PSA, Toyota, Daimler Chrysler and Honda). The total number of interviews carried out was 33, out of which 14 only at GMB that was the case study.

2. Although the concept of vehicle platform has different meanings for distinct assemblers, a quite wide understanding is the one which refers to the major systems underneath the body of the vehicle. Thus the major systems in a platform are powertrain, suspension, steering and the electrical system.
3. For Birkinshaw (1996), world product mandate gives the subsidiary global responsibility for a single product line, including development, manufacturing and marketing that extend the national market.
4. The experience related modular assembly was adopted for the first time by VW truck plant in Brazil (Resende/RJ), named Modular Consortium. The difference is that in Modular Consortium production model, the suppliers' direct workers are responsible for the final assembly line; in Industrial Condominium production model, the assembly' workers are responsible for the final assembly line.

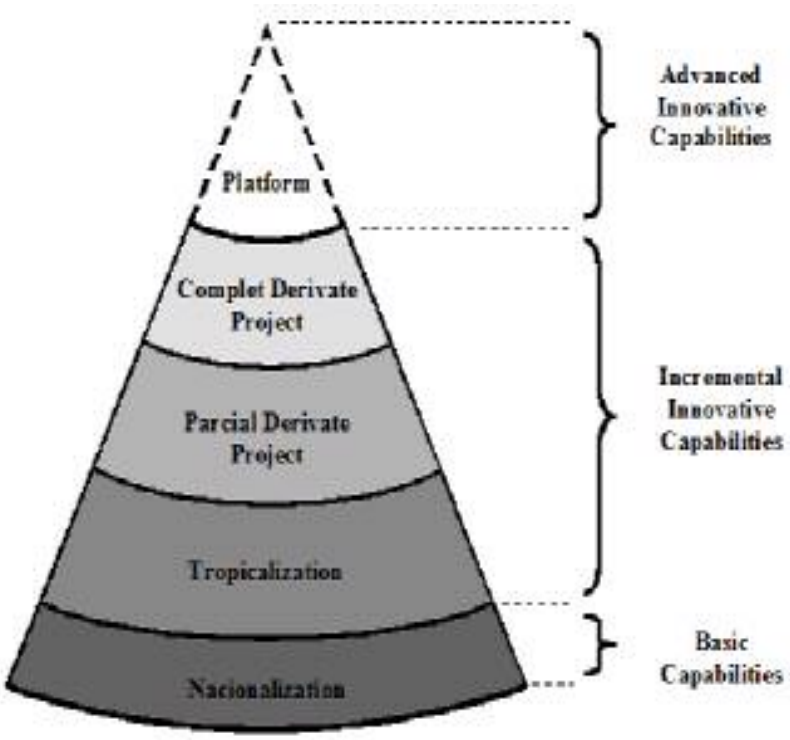

FIGURE 1

Classification of technological capabilities PD in Brazilian subsidiaries of lcarmakers