Modularity is a key issue nowadays in industry. Although it is not a new issue, it has growing in importance in recent years in the auto industry. The aim of this paper is not to discuss modularity theoretically, but to discuss some new production arrangements and new design strategies which are based on new forms of relationship between assemblers and suppliers, as well as on the use of modularization. The discussion is based on a field research in the Brazilian automotive industry, involving the main assemblers, some of the most important first tier suppliers and some few second tiers suppliers.

Brazil has been a ground proof for strategies based on modular concepts mainly in production (see Baldwin and Clark, 1987, to a categorisation of modularity: in design, in production and in use) and, to some extent, also in design. Since the announcement by VW of its “modular consortium” production model, many other experiences have taken place involving companies as Fiat, Ford, GM, Mercedes-Benz and Chrysler (before the venture), Renault, in greenfields or even in brownfields. Some suppliers are deeply involved in modularity; maybe Dana is the best known due to the “rolling chassis” supplied for Chrysler, but many other suppliers are on the same road. Modular production/supply tested in Brazil was in the centre of the North American discussion for the “transplant” of the “model” to US plants, mainly in the GM case and its so called Yellowstone project\(^1\), in Ford plans to modular assembly for the Focus and the Amazon project\(^2\), in Fiat discussions for the renewal of the Punto in Melfi, Italy\(^3\), and so on.

We will propose firstly a historical and chronological approach for modularity in the Brazilian auto industry. Then, by analysing the assembly plants that have introduced or are introducing modular assembly involving important parts of the future vehicles and involving suppliers in the production of the “sub-assembly” or “module”\(^4\), we will discuss some characteristics of

\(^1\) *Automotive News*, May 17, 1999, p.6.; *Automotive Industries*, May 1999. The GM Yellowstone plan to introduce modularity in some of its US operations was confirmed in interviews with suppliers in Brazil. See also *Automotive Industries*, November 1998, p.43-43; *Automotive News*, 29 March 1999, p.24j. There was also a discussion amongst UAW (United Auto Workers, the US automobile trade union) members on the subject – one of the authors was asked to send then some papers on the “Brazilian model”.

\(^2\) *Automotive Industries*, July 1999.

\(^3\) Data get during a seminar and discussions with researchers at University of Calabria in Rende, Italy, June 1999.

\(^4\) For simplicity, we are not going to distinguish between modules, sub-assemblies, systems and whatsoever.
modular production. And since for many medium and high volume assemblers and suppliers Brazil is a peripheral design basis for adapting vehicles (in a process named “tropicalisation”) or for the design of derivatives for Third World countries based on a predefined platform (subcompact cars, small pick ups, small station wagons, small 5 doors etc.), we will discuss design activities, modular design and the possibilities set for peripheral countries with a stablished industry and large market and production facilities.

**MODULARITY : BEYOND DESIGN AND PRODUCTION, A NEW WAY TO COPE WITH UNCERTAINTY AND SAVE INVESTMENT EXPENDITURES, RESHAPING BOUNDARIES AND THE BUSINESS OF THE COMPANY**

By modularity we mean not only a design strategy (modular design), a modular assembly or a modular maintenance (use). Actually, in our field research in Brazil, we have found that what firms call "modular production" has not necessarily the characteristics of "modularity" in the sense discussed by Sako & Murray (1999), for instance. The main characteristic of the so-called "modular arrangements" that have been carried out in the automobile industry is a new form of relationship among assemblers and suppliers that reshapes the boundaries of the industry and, to some extent, even the definition of the business and the risks linked to it (Marx, Zilbovicius and Salerno, 1997). Historically speaking, one could argue that modularity is not new even in the auto industry, since some companies used to dedicate plants or parts of a final assembly plants for some “sub-assemblies” like engines, gearboxes/transmissions, seats, wiring harnesses, dashboards, doors trimming etc. So, the concept of modularity we are discussing has a physical and a functional dimension of course (what is a “module”, a “system” etc.), but is much more than that. It is an option linked to a particular competitive game and business strategy of some assemblers to cope with their need to internationalise their production activities by saving investment expenditures, in an environment usually named by “globalisation”. This is why, in this paper, we will not make any distinction among modules, sub-assemblies or sub-systems.

By modularity we mean also more than physical proximity of the suppliers. One can argue that one can have modular supply with a supplier located far from the assembler. That’s true, depending on the volume and on logistical costs. But in our “modular package” we include other activities than design or physical delivery: modular consortium, industrial condominiums or alike means the assembler demands and the supplier is responsible for some services, like technical assistance for the sub-assembly, to participate directly in problem solving in the assembly line, to cope with scheduling changes and so on. We will return on the argument later, after a historical-chronological analysis of modular facilities in Brazil.

**The evolution of strategies based on modular production in the Brazilian automotive industry : a historical background**

**The modular consortium**

The “modular consortium” in the new VW truck plant in Resende was the launching basis for a systematic and widespread debate on modularity. Due to the end of the Autolatina venture with Ford, VW has to withdraw from the plant it is sharing with Ford to produce buses and trucks. This gives VW the opportunity of designing a whole new greenfield plant, based on the “modular consortium” concept, with the explicit aim to reduce the total investment by the assembler. At the time, the truck operation represented about 20% of VW do Brasil income in 1994-1995, and margins were much greater than for passenger cars. But VW did not have (and still does not have) truck and bus business outside Brazil; we have some indications that the “stand alone” Brazilian position was considered in the set of the consortium.

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1 In this sense, it is worth noticing that, up till now, each company adopts its own definition of what is a “module” or a “sub-assembly”, and there are differences even between departments in the same company – for instance, in an assembler researched last April, design department utilised a different nomenclature than the purchasing department. Nevertheless, in the literature we may find some interesting discussions on the definition of sub-assemblies, modules and systems- see, for example, Sako & Murray, 1999.

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1 For a deeper discussion on the model, and to follow the discussion at Gerpisa’s Colloquiums, see Salerno (1994, 1995a, 1995b); Marx, Zilbovicius and Salerno (1997).
In November 1995 VW began an experimental operation in a rented building. Although the production was very low (up to 4 bus chassis/day) and only the very final assembly was developed with the correspondent partners in that period, the impact of the announced plant was very high among other assemblers and suppliers. The new plant specially designed for the modular consortium was only partially inaugurated in November 1996, but important modules such press and body shop, and painting, were only inaugurated many months after.

- The model became famous due to the absence of VW’s blue collar workers in the plant, all run by suppliers’ direct workers. But perhaps some other features were more important to set the “paradigm” of modularity independent of who employs the direct workers. These features are:

- The investment agreement among assembler and each supplier that operates inside the assembly plant or in the surroundings (in the arrangement called “industrial condominium”, discussed below). The formal agreement between VW and the so called “modulists” suppliers is not public; it is considered confidential by all the companies involved. We could perceive, however, that apart from traditional clauses like prices reduction and supply assurance, there is one related to the amortisation of the invested capital and how “modulists” suppliers are paid. There is a fixed part of the payment, independent of the volume of production, related to amortisation – in that sense, it sounds as if VW have borrowed money from the suppliers. The variable part depends on the production VW has “accepted” after its own quality audits. The payment system according to the effective production instead of the planned one is an old demand of the assemblers: in early 80’s, GM made an unsuccessful attempt in that sense, promptly rejected by individual suppliers and also by the Sindipeças (The National Suppliers Association).

- The dedicated investment the chosen suppliers make in the assembler plant or in the surroundings. Although there are some few exceptions, the first tier (or “0.5 tier”) facilities are dedicated to the specific assembler plant. It means that suppliers tend to invest a minimum in these plants, just to cope with supply requirements (mix, short delivery times, assurance service etc.), keeping central plants with the highest capital invested.

- The integration between modules in design and modules in production. Although they can be different, many modules are (co)designed and supplied by the same company.

We have no definitive data on the efficiency of Resende plant. Some engineers interviewed consider that the plant is too big, with over capacity, and the basic design of the truck cabin is quite old. The plant runs in two shifts, and there are some internal complains on the quality of stamped parts – maybe due to the age of the design and the tooling. Anyway, from the market side, VW got more than 20% of the Brazilian market, generally speaking has lower prices than the competitors, forcing then to reduce prices and, maybe, margins. The game is still open since VW was searching for a strong international partner in truck business, and finally bought a heavy participation in Scania, also with strong presence in Brazil.

After VW Resende plant, Ford announced the restructuring of its Brazilian main plant by introducing the so called “industrial condominium”, asking some suppliers to set inside the site. But the main challenge was introduced just after by GM, who announced a “modular” plant to produce a new car (the Blue Macaw, a subcompact Corsa derivative) co-designed locally. When VW announced its “modular consortium”, there were rumours on a possible GM secret plan on modularity, plan that Mr. Lopez would have brought when he moved to VW. Anyway, GM approach to the Blue Macaw plant in Gravataí, near Porto Alegre, in the south of the country, is a mix between consortium (with parts of the assembly carried out by suppliers, like seats, tapestry) and condominium (with sub-assemblies supplied by companies with facilities in the site or in the surroundings, the carmaker continuing to assemble the final vehicle).

Afterwards, Ford, Renault, VW and Chrysler announced new plants or the restructuring of brownfields in the so called “industrial condominium” system.
The *Industrial Condominium*

The "winner" model for the new assembly plants not only in Brazil but also in other countries (Skoda-VW in Check Republic, Mercedes M-Class in the USA, Swatch in France etc.) seems to be the industrial condominium linked to sub-assemblies "modules" supply see Table 1.

If we take into account that more than 75% of the suppliers of VW São Bernardo plant – VW Brazilian headquarters, the oldest industrial automotive site in the country, an icon of Brazilian auto industry, as Wolfsburg plant is for Germany – are located no longer than 50 km from the plant, and that no one would consider today that plant as a “model”, it seems logical that condominium is much more than physical proximity. A condominium is different from an industrial park or a regional concentration of industries. Many cities around the world have attracted plants due to market conditions.

In a condominium, the assembler completely controls suppliers location. The assembler negotiates benefits with local governments, gets the land and the infrastructure, designs its production system thinking of “modules” of the product, defines its own internal operations and the subcontracted operations, the modules outsourced that should be produced nearby in the condominium or in the surroundings. This kind of organisation means an agreement between assemblers and suppliers located in the condominium characterised by much longer horizons than before. Typically, our research found agreements linked to part lifetime, not to orders size or term. The previous participation in arrangements such as condominiums and consortiums is being utilised by suppliers and recognised by assemblers as a differentiation factor in the search for new contracts, including those with co-design. This panorama would suggest us to think of proximity as the main criteria for supplying, but this is not really true, as we discuss just below.

**Mixed Arrangements : Between Modular Consortium and Industrial Condominium**

Although modular consortium, in its pure form, remains a unique case, lessons were taken. For most companies, trucks and bus chassis are very particular product, much more suited for radical modular production due to their own product architecture. Cars instead have different characteristics.

As can be seen in Table 1, some new plants present mixed characteristics: partial consortium (with the final assembly being carried out by the supplier), partial condominium (with final assembly being carried out by the assembler itself), depending on the sub-assembly, module or system. The closer to pure consortium is the Chrysler Dakota plant in Campo Largo, where Dana supplies the rolling chassis.

**What Changes with Modular Supply and Assembly?**

Proximity is crucial for some core sub-assemblies/modules, but not for all components. Receiving sub-assemblies instead of isolated components means different logistical questions and costs. An assembled dashboard has different logistical costs than their components have; an assembled seat is another typical example. At the same time, some processes have economy of scale and/or the need of fixed capital that make not viable to decentralise production according to each new assembly plant. For instance, Magneti Marelli made a US$50 million investment due to the new Mercedes A-class plant in Brazil. But only US$1 million went to the condominium, the rest being canalised to the main Marelli plant that produces components not only for Mercedes but also for Fiat. The facility in Mercedes condominium only makes some operations and final assembly of the sub-assembly. The same is true for dashboards, seats (the press shop for the structure of the seats being centralised), fuel systems, forged suspension parts, windscreen and so on.

Thinking of the whole sets of isolated components needed to build a car, proximity is not an imperative. Obviously, it depends on total costs (production costs, logistical costs, taxes etc.), on the strategic plans of the companies, policy of incentives. For instance, Ford relocated its future plant from Porto Alegre region (Gravataí) to Salvador region (Camaçari), more than 3.000km far from the original location, and 2.000km far from the main suppliers and from Ford’s engine/transmission plant (Taubaté, near São Paulo and the ABC).

Sub-assembly/"modules" supply means the assembler receives less but much more important “parts”, with greater value added.
<table>
<thead>
<tr>
<th>Assembler</th>
<th>System</th>
<th>Parts produced by the assembler</th>
<th>Suppliers in the condominium (proximity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW Resende</td>
<td><em>Truck/Bus</em> chassis modular consortium</td>
<td>No direct production. 7 productive modules run by suppliers; internal logistics and maintenance outsourced</td>
<td></td>
</tr>
<tr>
<td>Mercedes Juiz de Fora</td>
<td><em>A-Class</em> industrial condominium</td>
<td>Body shop, painting, final assembly. Press shop and axles in the truck plant (São Bernardo); engine and gear box from Germany</td>
<td>8 firms : seats, painted plastic parts, tires assembly, exhausts, dashboards, wiring harness</td>
</tr>
<tr>
<td>VW Taubaté</td>
<td><em>Golf/Parati</em> initial condominium</td>
<td>Press, body and painting shops, final assembly, thermoplastics. Engine/mechanics from other VW plants in Mercosur</td>
<td>in the surroundings : seats, axles, bumpers, wiring harness, fuel tanks, pressed parts</td>
</tr>
<tr>
<td>VW/Audi São José dos Pinhais</td>
<td><em>Golf/Audi A3</em> condominium with some consortium</td>
<td>Press shop, body shop, painting Mechanics and pressed parts from Mercosur (mainly São Bernardo and São Carlos) and Germany</td>
<td>seats, plastic parts, fuel system, axles, tires assembly, exhausts, lighting systems, cooling system, windscreen</td>
</tr>
<tr>
<td>VW/São Bernardo</td>
<td>condominium</td>
<td>Being restructured for PQ-24, a new platform between The Polo and the Golf</td>
<td>In definition. In a first look, similar to VW/Audi</td>
</tr>
<tr>
<td>Fiat Betim</td>
<td><em>Palio/Uno/Marea</em> initial condominium</td>
<td>final assembly, body shop, painting, engines, heavy press</td>
<td>suspension, bumpers, dashboards, exhausts, front (cooling system, plastics), seats, small-medium stamped parts</td>
</tr>
<tr>
<td>Ford Camaçari</td>
<td><em>Amazon</em> condominium with some consortium</td>
<td>Final assembly, body shop. Amazon : a new platform for a small van (1st model to be produced) and the new Fiesta (2nd model) Mechanics from Taubaté plant</td>
<td>13 suppliers below Ford’s roof; 10 in the surroundings painting, door assembly, front panel (with steering column), seats, trimming, bumpers, dashboard, tires assembly, front (cooling, lighting), engine/gearbox assembly, logistical operator</td>
</tr>
<tr>
<td>GM Gravataí</td>
<td><em>Blue Macaw</em> condominium with partial consortium</td>
<td>Press shop, body shop, painting. Assembly from GM and suppliers (in consortium)</td>
<td>sheets cutting, pressed parts, seats &amp; trimming, dashboards, exhausts, steering system, plastics, windscreen, cooling</td>
</tr>
<tr>
<td>Renault São José dos Pinhais</td>
<td><em>Scénic/Clio</em> condominium</td>
<td>Body shop, painting, final assembly. Engines in a plant nearby. Stamping outsourced Other mechanical parts from Mercosul and France</td>
<td>seats, exhaust systems and steering columns, cockpits and door panels, front and rear axles and tires assembly</td>
</tr>
<tr>
<td>Chrysler Campo Largo</td>
<td><em>Dakota</em> partial consortium</td>
<td>Assembly plant. Engines Detroit Diesel (located beside – only assembly) Chassis in consortium (Dana)</td>
<td>engines assembly, rolling chassis with 300 components (suspension, fuel tanks, wheel&amp;tires) : around 30% of Dakota cost.</td>
</tr>
</tbody>
</table>

*Source*: interviews with assemblers and suppliers; newspapers
In this "modular" system, the supply is responsible for delivery and technical assurance to the whole sub-assembly. This is quite different from the responsibility of a single part that will be further manipulated, manufactured and assembled by the final assembler: if a problem occurs on the line, the assembler must track it to look for its origin. But if the whole sub-assembly is delivered ready-to-be assembled for a supply in a just in sequence basis, the responsibility for problems is much easier to be set.

In that sense we consider that modularity, understood beyond subassembly delivery including a special organisation and managerial system between suppliers and assemblers, it is driven also by vulnerability and by service issues.

By vulnerability we mean a twofold concept: vulnerability of the production and vulnerability of the investment. For instance, Chrysler invested in Campo Largo, Brazil, only 32% of the total amount a fully integrated own plant would require (Automotive Industries, 1998) – rolling chassis, engines are produced in a modular basis in a condominium. So, the assembler needs lower investments to set plants, launch new models etc. Less investment in a plant means greater possibilities to cope with the need to spread plants in different continents/regions/countries, as well as lower risks in terms of profitability (see Marx, Zilbovicius and Salerno, 1997, for the risk sharing issue).

Proximity has many roles:

- to reduce logistical costs of sub-assemblies;
- to reduce inventories in the assembler due to just in sequence delivery according to its final scheduling;
- service relation. We would like to discuss the typical service relation in such arrangements.

Modularity as a Service Relation

New assembly plants usually are dedicated to one single platform, but each platform can admit many derivatives, options, versions etc. In order to set a pull system driven by sales, assemblers desire to postpone in extremis their production scheduling. To do so, they must have a co-ordinated and fast supplier system – proximity is crucial to reduce the gap between the component (or "module", or sub-assembly...) order and its delivery. In terms of "modulists" manufacturing strategy, it means that they must have a fast production system and/or inventories – time interval to deliver some modules can be less than 2 hours (e.g., seats).

The hidden side of the story our research put light on is what we call service relation. Many suppliers have considered that the most important issue is to be “present” at the client facility in order to react to quality or delivery problems (to solve them without stopping the assembly line), to quickly discuss with the plant some modifications in the component/module to better fit assembler’s characteristics and so on. On the other hand, as many modules are more complex than its isolated components - due to the fact that it is an assemble of components, which leads to several internal interfaces, along with the external ones - and as they are "black boxes" from the assembler's point of view, the need for a good, quick-respondent service is enhanced by the use of a sub-assembly/"modular" supply. For instance, one "modulist" have trucks in stand by just in case a problem occurs with the ones on route to the assembler, located few kilometres far away, and a special scheme to avoid the effects of river floods in the region. The same supplier has a resident engineer in the assembler’s line to deal with technical issues linked to quality although it has never had a rejected module by the client. The reason? “The client feels better with our support”, in the manager words. But, apart from this feeling, to provide a local service with specialised staff means proximity not only for the current operation, but also for future operations, in the sense that it permits to perceive and to anticipate clients’ movements in order to anticipate proposals.

In our main findings, proximity is a function of volume and logistical problems, but also – and in some case, mainly – an issue of service. First tier suppliers are delivering not also a whole sub-assembly just in sequence, but also technical assistance (sometimes with some of their blue collar workers and engineers working in the client’s facility), adjusting the deliverance to (frequent) changes in scheduling due to marketing issues or to productive problems of the assembler. For instance, if there’s a problem with the production of a version (e.g., the lack of an important component like the particular break), the assembler would desire to change the schedule. But to do so it has two possibilities: a) to maintain...
inventories; b) to have a supply system with reduce gap – this is important for components like seats and dashboards, very linked to the particular version of each vehicle (colour, tissue, instruments, optionals etc.) Modularity and proximity is not only a question of components price for the assembler or of wages, but a way to reduce uncertainties, anticipating local changes and adaptations in process and product design.

In the sense of product and process design, there are two types of proximity: the one to the headquarters (linked to future vehicles) and the one to the assembly plants (linked to current operations – also a way to be qualified to future business). Proximity to headquarters means no de-concentration of the main plants and of the main design staff. In Brazil, although most of the newer plants are located outside the traditional ABC region – the “Brazilian Detroit”, with a high concentration of local headquarters – the main suppliers are not thinking of moving their engineering and design facilities from ABC.

These types are coherent with the movement of capital concentration and the leadership of some few “global players” component companies. During the development of a vehicle, proximity means location nearby the development centre, in the headquarters or elsewhere: co-design partially carried out by Fiat (Palio model) and GM (Blue Macaw) in Brazil were based on local facilities of the main component companies. Adaptation to local markets and derivatives co-design for regional markets means proximity to local headquarters. Delivery efficiency and service day-to-day service relations means proximity to the assembly plant, say, to be part of a consortium/condominium.

A discussion on the technological and strategic risks of modular supply can be found in Marx, Zilbovicius and Salerno (1997) and in Automotive Industries (1998).

**DESIGN PROCESS AND MODULARITY IN BRAZIL**

Concerning the patterns of design present in the Brazilian automotive industry, three issues will be discussed in this paper: first, the presence of modular product and design. Second, the existence of different alternatives for product design strategy, ranging from the “world car” strategy (global, standardised product derived from a new platform) to the local design product based on an old platform (Sugiyama and Fujimoto, 2000). Third, the present product development organisation in assemblers and autoparts makers and the insertion of Brazilian subsidiaries or firms in this organisation. We will begin discussing the second issue.

According to Sugiyama and Fujimoto (2000), there would be four basic strategies in product design:

- Global design product using newly developed platform (global standardisation);
- Local design product using newly developed platform;
- Global design product using old platform;
- Local design product using old platform.

Global design aims to reduce development costs and time, since the design activities might be realised only once for a model that will be produced in a “global” or, at least, a larger scale. But sometimes it may be difficult to meet specific needs of the local markets; also, products conceived for markets of developed countries may be too “sophisticated” for consumers of emerging countries, whose purchasing capacity as a rule is lower, a problem known as “overdesign” (Sugiyama and Fujimoto, 2000; Fujimoto, 1999). On the contrary, local design does not permit the development cost and time savings related to the global one, but the needs of local consumers are more easily fulfilled.

The option for a new or old platform based strategy also have advantages and disadvantages. Concerning the old platform strategies, the advantages relates to the usage of already proven and well-known technologies of production, leading to fewer production problems. But consumers may not approve an old design and technology, refusing the product. On the other hand, new platform strategies may suffer from overdesign problems.

Before the nineties, we had observed in Brazil the presence of the third and fourth product design strategies mentioned above. For example, VW was one of the companies which clearly followed the fourth alternative; it might be considered in Brazil one of the most decentralised companies concerning engineering activities – but actually
these activities have been, most of the time, dedicated to adaptation of old platforms originally conceived for the central markets. Nevertheless, in some cases the local design gave birth to unique models, which may be, in a way, considerate Brazilian models – as the Brasilia or the Gol. These previous activities would have led to the consolidation of some competencies in product development in the Brazilian subsidiary.

The opening of the Brazilian automotive market in 1991 marked a change in these strategies. Due to the possibility of exploitation of the Brazilian huge internal market as well as the whole Mercosul market, car assemblers and autoparts producers have decided to (re)invest in Brazil, either by inaugurating new plants, modernising the existing ones and changing the product portfolio in order to face a fiercer concurrence. This last point meant also a change in the product design strategy, from global or local design using an old platform to a global or local design using newly developed platforms. Actually most of the products introduced in the Brazilian market in the last five years and produced in the country are vehicles conceived as global products, on new platforms, but adapted to local or regional markets. These adaptations – or “tropicalisation” – are necessary since there may be some differences among the target markets of the global product; there may be some differences in the customers’ preferences, or in the local conditions of usage or yet in the scale of production, which may demand a different process and/or some differences in the product. For instance, Mercedes Benz A Class was launched almost simultaneously in Europe and in Brazil. The Brazilian model has suffered some adaptations due to different climate, fuel, roads and general conditions of usage.

If this alteration in the strategies meant, on one hand, the modernisation of models and their production process, and to some extent the introduction of new technologies of process and design, on the other hand it promoted a general “downsizing” in the product engineering departments of the companies. As an illustration, VW had 1800 employees working in the product engineering department; nowadays, this number fell to 600. The second important issue concerning the design strategy in assemblers and autoparts makers is the configuration of the product development process. Sugiyama and Fujimoto (2000) argue that a key factor in determining the type of organisation is the choice of location of the product development activities, which can be home country or subsidiary based. There may be a centralisation of the process in the headquarters, therefore in the “central” countries; or a decentralisation of the development, with the participation of the subsidiaries. From the point of view of the technological development of emerging countries, the later would be the most interesting strategy because it may lead to a competencies building process, which collaborates to the creation and consolidation of “superior” competitive advantages (Porter, 1991) – and these, in turn, may lead to a sustainable economic growth.

Global product development may imply in a concentration of the activities of product development in the headquarters. In fact, this centralisation is recognised as one of the advantages of a global product, as the development costs are reduced due to the existence of an unique development centre. Even the adaptation of global products to local conditions, or “tropicalisation”, may be concentrated in the headquarters. In Brazil we have found empirically examples of either concentration and de-concentration of adaptations. For instance, Mercedes-Benz A Class and Renault Scénic were totally developed in the headquarters, even their tropicalisation. On the other hand, Fiat Palio and GM Blue Macaw were partially developed in Brazil, with the participation of Brazilian engineering teams from the assemblers and the suppliers.

Modularity and decentralisation of design activities

The "modular" product and design may facilitate a decentralisation strategy, since it may not be necessary to develop every part at the same place. Given the main characteristics of each module, its development may be done in a black box way. Even if there is co-design or grey box development – that is, suppliers’ participation in the design process – , this does not mean that all the development activities must be realised altogether – actually, the development of each module, independent by definition, may be carried out in parallel processes, thus reducing the time-to-market of the final product.

The existence of a modular product facilitates co-design itself, inasmuch as it is much more
complex for the assembler to co-ordinate the work of different suppliers developing hundreds of isolated parts, which should after be put together by the carmaker, than to co-ordinate the design of a few modules by a few suppliers. The modular product reduces the number of interfaces that must be managed by the assembler.

In which refers to the specific needs and preferences of different markets in opposition to a global, standardised product, the adoption of modular design may be a way to obtain “the best of two worlds”. Modular design helps to maintain the advantages of a global product and at the same time to respond to the requests of the different markets, due to the possibility of creation of some common modules which will be shared among several different models; the differentiation itself may also be made through the design of different modules (Bartlett and Ghoshal, 1992). Modularity also makes it easier to locally adapt some of the modules without changing the basic vehicle concept – the second and fourth alternative presented by Sugiyama and Fujimoto (2000), local design based on a new or old platform.

Therefore, if there is any need of centralisation in the product development, it does not come from modularity; on the contrary, modularity itself makes it easier to de-concentrate and, maybe, to profit from any competitive advantage on design that may exist in the headquarters or subsidiaries of suppliers and carmakers.

Given this scenario, partially made possible by modularity strategies, we have some evidence that Brazil is being consolidated as a “peripheral” product development centre, due to the size of its market, to the importance the country has in the whole business of some companies (like Fiat, GM, VW), and to the existence of some competencies in specific areas of product design, specially concerning “popular” vehicles, suspension, engine adaptations etc. We have found some interesting cases of product development being made in Brazilian subsidiaries of transnational companies, either carmakers or autoparts firms; in these cases generally the Brazilian subsidiaries are responsible for the creation of a derivative model, or the adaptation or the design of some parts or modules over a pre-developed platform. In other words, using the definitions from Clark and Fujimoto (1991) concerning the stages of design process, the basic product concept is defined in the headquarters, as well as the advanced vehicle design and styling. The co-ordination of the whole process is also in charge of the central offices. The design process is decentralised towards the subsidiaries in the later stages – component or module design, prototype, building and testing and process engineering.

Fiat’s Brazilian subsidiary, Fiasa, is an interesting example of how this decentralisation may take place. At Fiasa there are two main possibilities of joining a global product development process. The first one is to be responsible for the adaptations of products or platforms for local or regional conditions; actually this is one of the competencies of the Brazilian product engineering department, together with the development of local suppliers, the testing of the final model and the nationalisation of components. For instance, the 178 Project, which gave birth to the Palio and Siena models, was developed with the participation of Brazilian engineering teams from Fiasa or even from some suppliers of modules, with whom there was a co-design scheme. This participation occurred only after the stages of product concept definition and advanced design and styling of the vehicle. Brazilian engineers and purchasing executives went to Italy for some months during the stages of basic definitions. After this period, the design process was centralised in Brazil, under the co-ordination of Fiat Italy. The same process is taking place at present with the re-styling of the Palio model; however, as this is not an entirely new platform, the participation of Fiasa has been more significant, since there are not so many activities of conception and styling as there would be in the conception of a new platform.

But Fiasa may take part in a global development process in another way. Fiasa has two “excellence centres” for product development of the company, along with another four centres, all of them located in Italy. The Brazilian centres are responsible for the development of some specific components for motors (to deal with bad quality or alternative fuel as ethanol) and for the development of suspension modules. This means that even if Fiat is developing a product not target for the Brazilian or South American market, it can delegate to Fiasa the responsibility for the development of these

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1 By regional we mean not only Mercosul, but al the Third World countries Palio and derivatives are produced or sold.
modules or specific components – always under the co-ordination of Fiat Italy.

Fiasa is one of the assemblers’ subsidiaries most integrated to the global product development process of their headquarters. A good example is the 178 restyling: according to the budget, Brazil has 50% of the design hours, an Italian specialised company (Stola) has 39.4% and the central design headquarters only 10.6%.

We may find different situations if we look at other carmakers in Brazil. GM, as mentioned above, is to launch the Arara Azul, co-designed in Brazil. VW, firstly, has decided to reduce local design activities regarding the next platform/family (PQ-24), but has turned back, because it would cost less to “tropicalise” and to develop derivatives locally. Ford has increased its design engineering, sending 60 engineers to participate in the development of the Amazon platform in Dearborn, USA. We have already mentioned the case of Mercedes Benz A Class, that represents a more centralised design process.

On the other hand, if we look at Brazilian autoparts companies, we will notice that in general they do not participate in co-design with the assemblers. In most of the cases they simply develop the production process to a given product, designed by their clients. In case they supply a very simple product, they can design it in a “supplier’s proprietary part” way.

Since modularity do not determine the centralisation or decentralisation of the global product design process, and since we may empirically find examples of either one or another configuration, which would be the key factors to shape the global product development organisation in which refers to location of activities? There are no easy answers to this question, as there are many issues, of different natures, which may influence the decision of where to locate the activities of the product development process; but we are able to draw some alternatives from our empirical research in Brazil.

The path, or administrative heritage of each company concerning the product development strategies, for instance, plays an important role in this decision (Sugiyama and Fujimoto, 2000; Bartlett and Ghoshal, 1992). Looking at the trajectories of the carmakers in Brazil, we may notice that there are some companies that has always showed a greater intensity of product development or adaptation activities in their subsidiaries than others. VW is one example, as we mentioned before. One hypothesis is that along the years the existence of some product development or adaptation activities have created some technical competencies in the subsidiaries, and then the company could profit from these existing competencies in order to adapt old or global products or to develop local or regional products, creating a “virtuous circle”.

In the Brazilian autoparts industry, we can also find examples of transnational companies profiting from previously developed competencies in product engineering. During the nineties, specially after the Automotive Regime in 1995, the autoparts sector suffered a strong concentration and internationalization, and many traditional Brazilian companies were acquired by transnational companies. Some of these Brazilian companies had developed technological competencies in specific fields. After the acquisitions, the transnational companies have centralised the product development process in their headquarters; but, in some cases, the competencies developed by the Brazilian company were not found in the transnational company. Thus the Brazilian subsidiary has become the global product development centre for the products related to those competencies. For instance, Metal Leve, a Brazilian autoparts company, had developed competencies in the design and production of bearings. When Mahle bought Metal Leve, it decided to maintain in Brazil the research centre for bearings, as Mahle itself did not have the technological competencies for the development and production of bearings.

Some authors argue that the kind of knowledge necessary to develop a product would influence the decision of whether to centralise or not the development. Subramanian et al (1998) and Carrincazeaux and Lung (1997) shows that in the product development process we may find both tacit knowledge – which can not be easily codified and transmitted – and explicit knowledge. For instance, it is more difficult to determine the preferences of each market than the conditions of the roads in a given country. Sugiyama and Fujimoto (2000) add that even some information necessary for problem solving in the development process may be “sticky”, or difficult to transfer, similarly to the tacit knowledge.
If the tacit knowledge or “sticky” information are important in the development process, the physical proximity becomes also more important, because it is more difficult to transfer it to another person. Fiat’s Brazilian subsidiary, for example, is responsible for the adaptation of products to other countries in South America, South Africa and countries with similar road conditions. I means a particular development for each country, because conditions and consumers “taste” are never the same.

The companies we have studied pointed to the fact that the Brazilian subsidiaries can be more agile to identify adaptation needs and the solutions for these adaptations, since they are closer to the consumer market; in addition, sometimes the best solutions come from the competencies of local based suppliers. But, to have a broader panorama, one must develop a quantitative research, a path our research group is following, but research is just in the beginning.

The importance of tacit knowledge or sticky information in the product development process and the existence of local competencies may influence, but hardly ever determine the localisation of a complete structure for product development in Brazil. Another key factor is the production scale. For example, the carmakers that entered the market and inaugurated plants in Brazil after 1991, often with a production scale much lower than the previously established companies, as a rule did not create a strong structure for product development in Brazil, as it would demand a great amount of investment. Their technical departments generally look after some small adaptations and mainly technical assistance to customers.

Also, as argued previously, the importance of the subsidiary in the business of the parent company helps to define whether the subsidiary will or not participate in the design process, as well as the extent of this participation. In Brazil, subsidiaries of VW, GM and Fiat, which contribute heavily to the economic performance of their parent companies, have stronger participation in their product design processes, in comparison with other subsidiaries as the Mercedes Benz (in the car business, not in truck business), Ford, Renault and Chrysler ones, for instance.

Finally, the choice of whether to concentrate or not the product design process is also affected by some industrial policy issues, as the existence of public direct incentives to local product development activities and the existence (or potential for) of technological infrastructure, universities, research institutes, workforce education etc. Thus the governments play an important role in the attraction of product development activities to their countries. In Brazil we have observed that this question is not in the agenda of neither the national nor the regional governments. Despite the presence of “bidding wars” among several states, characterised by the providing of lands, infrastructure, tax breaks and loans by the states (Arbix and Rodríguez-Pose, 1999), these disputes aim only to increase local economic activity and generate employment through the establishment of plants of assemblers and suppliers to their territory. There is no discussion on subjects such as establishment of local technological centres, or the participation of local workforce in product design activities.

CONCLUSIONS

We tried to characterise modularity as an organisational and managerial broad issue, linked to particular business strategies which emerge with the internationalisation of the auto industry.

In that sense, modularity is a broader concept than modular design, assembly or use, it is linked to Regarding the design strategies in the automobile industry, we could raise an hypothesis for further research.

Modularity would make easier to develop strategies characterised by a decentralisation of the design process – either between assemblers and new service relations between car and parts makers, to a definition of the boundaries of the companies, and to investment risks. In the research agenda, it lacks a discussion on the suppliers side of the game.1 suppliers or between headquarters and subsidiaries – as the development of local products based on a platform centrally designed, and co-design.

However, it does not determine the choice for these alternatives; there are many important factors

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1 See FT.com web site, February 29, 2000 : Supplier parks: economies of scale plays a vital role, and: Components: transformation underway, both articles by Tim Burt.
discussed in this paper, such as the existence of local competencies on design, the presence and importance of tacit knowledge in the design process, the importance of the subsidiary to the performance of the company and the existence of incentives by the government, among others.

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