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KNOWLEDGE TRANSFER THROUGH THE SUPPLY SYSTEM: DOES MODULARITY MAKE IT EASIER?

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INTRODUCTION

The relevance of knowledge and technology may explain why companies avoid sharing information with their competitors and sometimes even with partners. In the auto industry, a very competitive environment, some of these assets may be acquired in the market, but others are intangible and unavailable. However, since modularity and outsourcing became strategic issues for assemblers, and as outsourcing means basically to transfer activities and responsibility to suppliers (upstream), the hierarchical structure of the supply chain tends to be more interdependent. The question raised in this paper is whether this modular strategy makes the information flow easier among the companies involved in the production of cars and components.

In order to explore this argument, the paper presents a comparative analysis between two plants of a single assembler. The products (passenger cars) are similar and fit into the subcompact category, that is the most representative market segment in Brazil (more than 70% of sales in internal market). The interesting fact is that the similarities between the two products are not extended to their production system; one car is assembled in a conventional plant and the other, in a modular one. Besides some particularities of each plant, the main factors of distinction are the degree of modularity, and mainly outsourcing

A brief review on main concepts related to the implementation of modular strategy by the automotive industry is presented initially. Following that, we describe the supply system of both plants in order to identify the similarities and differences among them. The idea is to verify if the modular system offers more opportunities of knowledge transfer than the conventional plant. If the argument is true, it is important to understand the impact on the tiered suppliers.

The research was conducted as a case study. To compare the car made in the modular plant to the one assembled in the conventional plant we have chosen two modules in both cars - front suspension and cockpit. The reasons for that decision are the level of added value - cockpit is the larger module (in terms of number of components) and level of complexity of

the components. The research was conducted with the assembler (also called car assembler or automaker), the systemists (also called module suppliers, Tier 1 or first Tier suppliers) and the producers of components (also called Tier 2 or second Tier suppliers). During 2002 we interviewed people responsible for purchasing, product engineering, manufacturing, logistics and quality.

MODULAR STRATEGY IN THE AUTOMOTIVE PRODUCTION – HOW DOES IT AFFECT THE SUPPLY CHAIN?

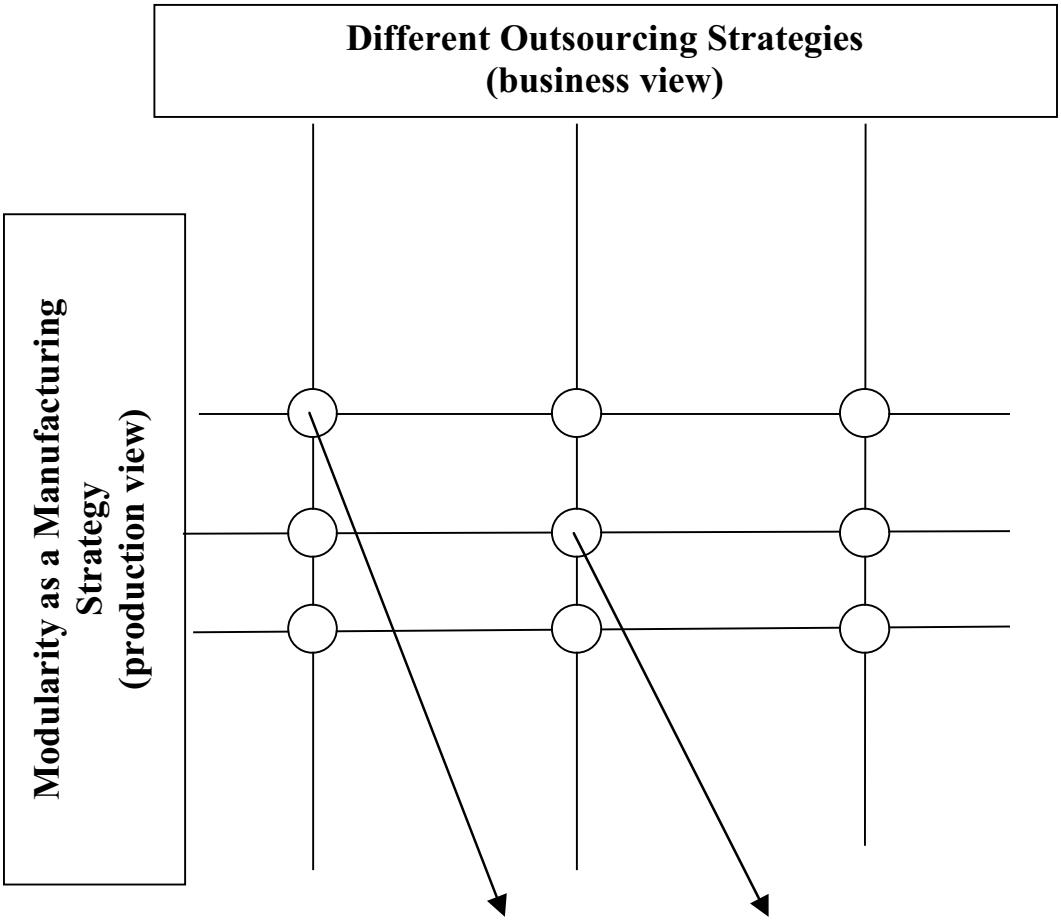
In the last years the auto industry has implemented, at different degrees, a competitive strategy based on modularity and on outsourcing. As shown in Figure 1, one of the main characteristics of the modular strategy is to approximate assemblers and some first tier suppliers, those producing systems and modules (also called systemists).

The proximity is first of all geographical, since systemists tend to locate as near as possible to the final line, in order to assure the efficiency of the modular supply. It means delivering in a just-in-sequence basis, providing fast technical assistance, keeping the inventory of components and final products (which are determined by the assembler) by themselves and also sharing facilities costs with the assembler. In a second perspective, the systemists get closer to the assembler's operations because they assume the module assembly and eventually they also manage the Tier 2 suppliers. Third, these suppliers work directly on the development of the modules and components, what makes the integration with assembler more concrete.

First of all, it is important to mention that these two concepts are not new in the auto industry, and that they have been used a lot, but separately. The automakers initially saw outsourcing as a way of transferring the production of components for suppliers; consequently they could focus on the most added-value activities. This movement resulted in the creation of companies like Delphi and Visteon. Pre-assembled modules in the final line were also a common practice for some assemblers. The relevance of modular strategy today is that it combines two ideas and solves very specific and current demands of the assemblers. How to reduce the production costs meanwhile one reduces the risks of investment? How to reduce significantly the inventory levels with no penalty for operations?

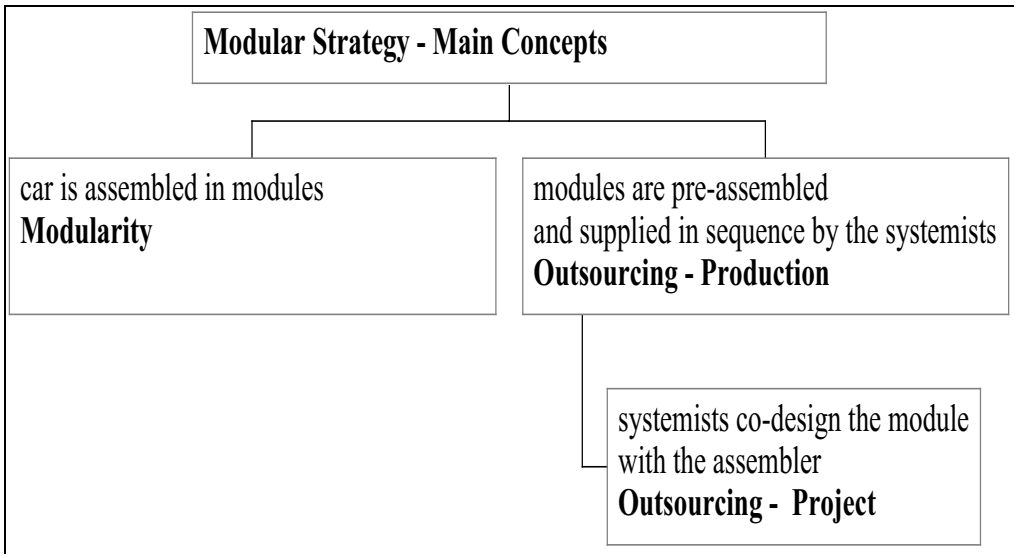
The modular strategy is, therefore, more than modularity plus outsourcing. It is the reason for so many changes in the supply chain, namely the new role of systemists, the importance of logistics (as a strategic area in companies) and the creation of several new configurations for auto production in the world.

Figure 1. - *Modular Strategy*



The scheme on Figure 2 is a brief and synthetic view on the modular strategy, but it does not express all possibilities for that.

Figure 2. - *Modular Strategy – Main Concepts*



In other words, a vehicle is not totally divided into modules (some parts may remain individual), neither all modules are outsourced from systemists (the automaker may pre-assemble some modules indoor), nor all components are designed by systemists (some parts are still developed by assemblers). One should also say that despite the growing relevance of first tier suppliers, the decision-maker is just the assembler, and nobody else. It determines which parts of the vehicle will be become modules and which tasks will be performed by the systemists. Therefore, based on the logic of modularity and outsourcing exposed on Figures 1 and 2, each assembler designs its own strategy depending on its objectives.

To sum up, we believe that the modular strategy should be seen as a 'conceptual package', which includes several ideas. A very relevant one is the division of the vehicle into a few parts (complete pre-assemblies called modules or systems) in order to make the vehicle's final assembly faster and less expensive. New roles are created for some special suppliers - the systemists – as long as they assume more responsibilities for design and manufacturing. Finally, relations between these suppliers and the car assembler get much closer.

Modularity

In auto industry, modularity means basically to divide a car into few modules in spite of a very large number of isolated (spare) parts. Assemblers have used it as a way to optimize the manufacturing and sometimes the development of cars. It helps reducing the number of tasks and simplifying the final process and the amount of handled parts during the final assembly; diminishing the inventory level; speeding the final assembly and also reducing the number of direct suppliers. In a very simple way, the idea is to join several components so

that, in spite of dealing with many spare parts, the assembler handles just one module or system. Typical modules are seats, panel, suspension, motor, exhaust and doors.

Modular production was first used in computer industry as a way to diversify production and offer a wider mix of computers. Starr [1] described the innovation as a solution, since mass production did not allow achieving the higher level of variation demanded by consumers at that time. As the modular production permits to delay the finalization of the product, and as the modules can be put together in different ways, the extra time can be used to produce different versions of a same product, according to the consumers' needs.

According to Baldwin & Clark [2] modularity is a solution to conceive a product or process of growing complexity. The modular system is decomposed in parts that are projected and produced separately, although they function as an integrated set.

As a concept, modularity may be applied to design – by dividing the development of a product into modules of activities, which are then conducted in parallel [2]. The result is less time spent in the conception of products. Simultaneously, it can speed up the technological changes in the modules, whenever the supplier in charge of the module's development is an expert in that technology (this idea also refers to outsourcing). In auto industry, however, modular design is not very often. Just a few parts are developed under the modular logic and usually the modules are composed by spare components (that are developed individually), not as sub-assemblies or modules.

Modularity is also related to production. The division of the product into pre-assembled modules simplifies and speeds up the final assembly (due to the reduced number of parts that compose the product) and reduces the lead-time [2]. This is because the modules are pre-assembled in parallel and not sequenced, like in the conventional system [3]. It also allows increasing the variability of the product with no significant increase of costs. As the system permits to delay the finalization of the product, and as the modules can be put together in different ways, the extra time can be used to produce different versions of a same product, according to the consumers' needs. To sum up, modular production helps to reduce the inventory level of finished products and helps the producer to respond more efficiently to the variations of the demand [2].

The logic of modular production is to separate the standard tasks from the most complex ones [4]. The complex tasks are taken out of the final line and pre-assembled as modules, what may be made by the assembler or a supplier. As modules are put into the car as complete sets, in spite of many complex tasks in the final assembly, the producer deals with less and simpler operations. Meanwhile the complexity is transferred to the previous stages of the productive process (maybe a supplier), the producer gains extra time to correct defects, panes or even to modify the scheduling. It also reduces the final line extension, what means less investment in equipment and in the plant itself.

Outsourcing

If focused on modular production, outsourcing means that a first tier supplier produces the module's components indoor or buys them from another firm. First tier suppliers (also called systemists) pre-assemble the modules and deliver them to the final line. From the point of view of the systemists, modularization increases the added value of the product and maybe of the business. For an assembler, meanwhile the systemists assume a major part of the

manufacturing and purchasing, the assembler can focus on more profitable activities, like platform design, vehicle concept, styling and motor system, etc. The principles of outsourcing are core competence and transaction cost, two current concepts in business and economics [5].

In Brazil, the level of outsourcing has increased in the automotive production. It is exemplified in three modular plants - Volkswagen in Resende, Ford in Camaçari and General Motors in Gravataí [6]. At VW truck plant, the systemists do most of the processes, including the assemble of final product [7]. In Sao Bernardo, another VW plant in Brazil, the participation of first tier suppliers is restricted; they are not in the final line nor they assemble complete and complex modules. These suppliers do some sub-assemblies like shock absorber, but they do not supply the whole suspension or interior module (like in the Resende plant). According to some executives, the car production is a core business to VW and it shall keep the process indoors. GM agrees that assembly should not be outsourced because it is a core business. It is more difficult to guarantee assembly process quality if it is done by anyone else than the assembler. Such a risk GM is not willing to face in any plant - even in Gravataí. On the contrary, in the newest Ford's plant in Camaçari (a city located in Bahia, northeast Brazil) the level of outsourcing is expected to be higher than in any other car plant in the country. According to Ford representatives, some suppliers of modules will participate on the final assembly.

Outsourcing is also associated to the project of modules yet this practice, known as co-design (to share modules' design with suppliers), is not so often as the outsourcing of productive tasks [4]. It depends on the strategy developed by each assembler, on what it decides to outsource [2]. According to them, when a firm assumes the design of a module, it has to be in contact with all firms that will develop the other modules, because this interface is crucial for the success of the whole process. Whenever it happens, the assemblers face the risks of sharing much information and knowledge with their suppliers.

The experience of modular plants in Brazil shows that the practice above is not very diffused yet. Usually the assemblers coordinate the productive chain and do not outsource completely the design of modules from their suppliers. In VW truck plant Resende (a modular consortium), the assembler plays a central role in engineering and purchasing. At Anchieta plant in São Bernardo do Campo (a city nearby São Paulo, Brazil), recently restructured to operate as modular assembly, VW has worked more integrated with suppliers of subassemblies. However, they are very far from having total control over their own suppliers and over what and how Tier 2 produces.

The assembler studied in this case is another example for that situation. It developed a variety of outsourcing strategies, what has determined two main different roles for the first tier suppliers. Meanwhile one assumes totally the module development, another supplier simply assembles the components and has few contact with sub-suppliers (Tier 2). The phenomenon is in concordance with the argument of Baldwin and Clark [2] about the influence of assembler's strategy on the supply chain.

The next section explores the differences between the two categories of suppliers, as well as their relation with the information flow among suppliers and assembler.

THE MODULAR PLANT AND THE CONVENTIONAL ONE COMPARED

The choices made by an assembler in relation to the plant structure and organization depend on the vehicles to be produced there, and this is determinant for the conception of the supply system. The project of the car is, therefore, the starting point for planning the operations and supply structure.

The car made in the conventional plant was launched in Brazil in the 90's based on a project developed in another country. However, the original project passed through several adaptations meanwhile new versions were conceived by the local R&D center in Brazil. Some of these versions were also launched in external market. Some years after having launched the first car and counting on a high level of expertise acquired with the development of this segment, the assembler decided to conceive a new car in Brazil. The main goal for the modular program was to launch a new car based on the first one's platform but it should be less expensive than the first one. As we will relate next, together with the car design, the productive system is very much related to the success of the program.

In order to achieve its goal, the assembler decided for a new concept of productive configuration based on higher levels of modularity and outsourcing. The supply system was designed simultaneously with product and assembly process to make the production as lean and efficient as possible. The modular plant is dedicated to one platform and to some derivatives, meanwhile the conventional one produces three platforms.

The modular plant operates within an industrial park together with some suppliers that are very near to the final assembly. Proximity allows reducing the transport time as well as the inventories, since the suppliers deliver the pre-assembled modules to the final line. Gullander & Larsson [8] mention other benefits of the short distances as frequent personnel interaction and lean management.

The productive area in the conventional plant is much larger than in the modular configuration because there is no warehouse at the assembler plant in the last one. Almost all inventory of components is now at the systemists facilities co-located in the condominium, since they deliver more than 70% of the car. The logistical system was planned so that the modules are sequenced delivered. Besides this, systemists have also to provide services like faster problem solutions directly in the assembly line. All these reasons explain why the assembler decided for the condominium.

The choices made by the assembler concerning to the structure and organization of plant also influenced the components production. In the modular plant, the amount of parts of the car delivered as modules or sub-assemblies is much higher than in the conventional one. Besides, some modules (like exhaust system) are delivered to the modular plant with more components (more added-value) than to the conventional one. Finally, the content of the new car has more sub-assemblies meanwhile the other one has more spare parts. This is a demonstration of the assembler intention to turn components into modules. The changes in projects involved assembler, suppliers in tier one and tier two (explained bellow). Concluding, the assembly of both cars uses the logic of modular supply but it is more intense in the modular plant.

INFORMATION FLOW IN MODULAR AND CONVENTIONAL PLANTS

The comparison between the two supply systems is based on the different levels of modularity and outsourcing implemented on either design or production process in both plants. We have studied part of the supply chain of two modules - suspension and cockpit - in each plant. The supply structure in the modular plant is composed of three level (car assembler, systemist and component supplier (Tier 2 supplier), meanwhile in the conventional plant there are two levels: car assembler and component suppliers.

In order to better understand the situation, let us mention that the relationship among assembler and first tier suppliers has more than one single format. We identified two categories that describe the role of suppliers: full integrator and manufacturer. The only task they have in common is to assemble the module.

Full integrator is the first tier supplier that assumes the development (design and prototype), produces some components, tests the components, selects the Tier 2 suppliers, audit quality and negotiate with suppliers. However, it does not assume completely the tasks, because the whole process is watched carefully by a group of the assembler's engineers. In this arrangement, the assembler purchases the module as a kind of black box, what reduces to a minimum its control over the components' technology and price. For a full integrator, the modular approach adds more value because besides selling a black box, it sells services related to quality of components and sub-suppliers management. This is not a problem from the assembler's point of view because one of the modules is not considered strategic. The other one, more critic and value added, continues to be produced by the assembler in its conventional plant. By doing so, assembler reduces the chances of loosing expertise in the business.

The second category – ***the manufacturer*** – is the supplier that buys or produces the components and pre-assembles the module. Here the level of influence of assembler is much more evident, for it indicates the sub-suppliers (Tier 2) and fixes the prices of components. The systemist is not responsible for design of component. To sum up, we could say that besides less autonomy, the 'manufacturers' have obviously less profit margins than the 'full integrators'.

Suspension

In the suspension module, a first distinction among the plants is the extra hierarchical level found in the modular chain, that is the position occupied by the systemist. The schemes in Figures 3 and 4 show that the systemists (Tier 1) pre-assembled both modules at the modular plant while Figures 5 and 6 represent the conventional organization, where the assembler does the work by itself.

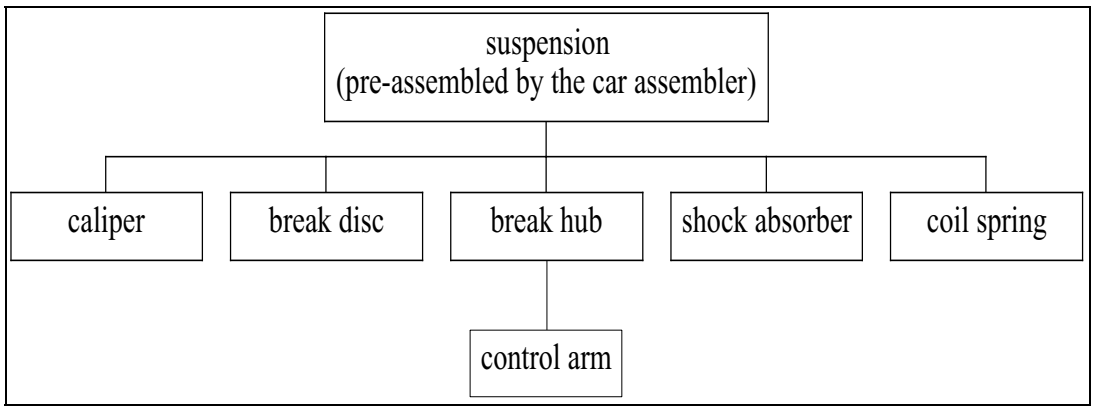
In both cars the suspension content and added-value is equal, either the number of parts contained in the module (approximately 30 components) or the characteristic of the components itself. All parts are carry-over.

Originally some components of suspension of the newest car were changed by the assembler according to its search for simplification and cost reduction on production. However, after having detected a design problem, the assembler decided to substitute that component, as well as all components linked to it, by the same parts used in the other car (the

one made in the conventional plant). The substitution was made after the car had been launched, as soon as the problem was detected. However, as the car was already on market, it was too late to start a new design and to test a new prototype. Commonality was the less expensive and fastest solution. The lack of time was definite to the assembler decision in that moment. Since then, the suspension modules of both cars are equal.

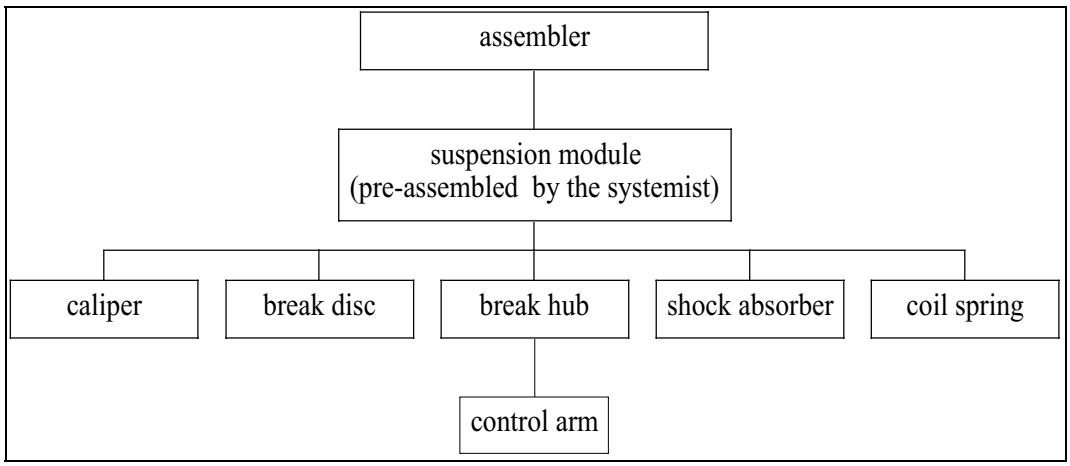
It is interesting to mention that the conventional plant also had a systemist supplier responsible for pre-assembling the suspension up to the end of 2001. The company was the same one that plays the role of systemist in the modular plant. However, for several reasons, like frequent quality defects, delays on schedule and also some organizational conflicts, the assembler decided to internalize the suspension pre-assembly (Figure 3).

Figure 3. - *Supply Chain of Front Suspension in the Conventional Plant*



In the modular structure (Figure 4), the systemist does only the pre-assembly; it does not produce any component of the module, it has not designed any component and it did not choose the Tier 2 suppliers. Commercial terms like prices and prizes are all defined among assembler and Tier 2, so that the systemist just purchases the components and pays for them. The systemist participates on the final validation with Tier 2 and, together with assembler, it controls quality of components.

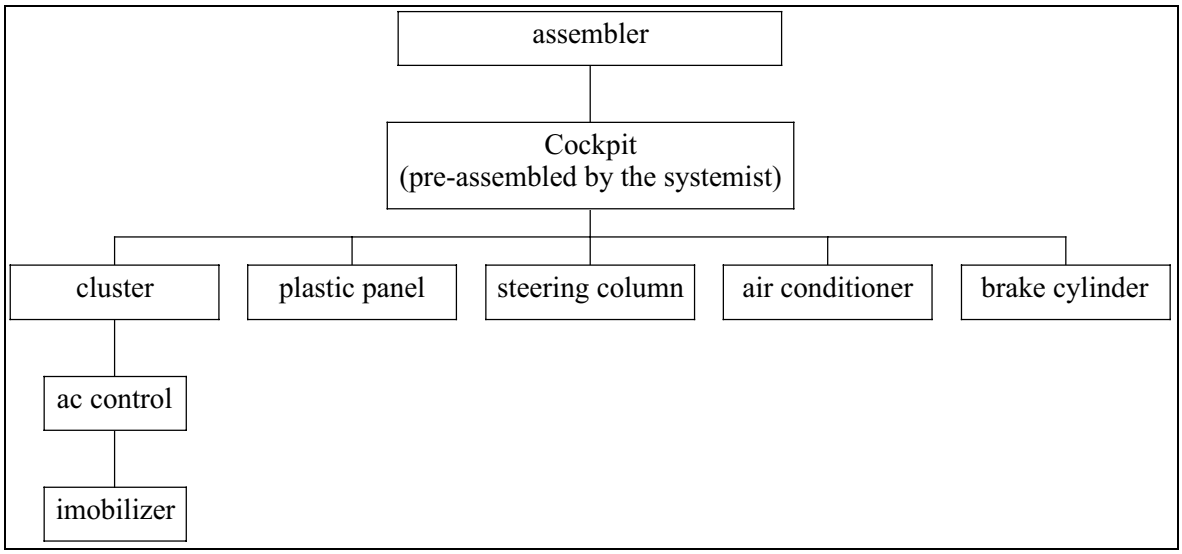
Figure 4. - *Supply Chain of Front Suspension in the Modular Plant*



Cockpit

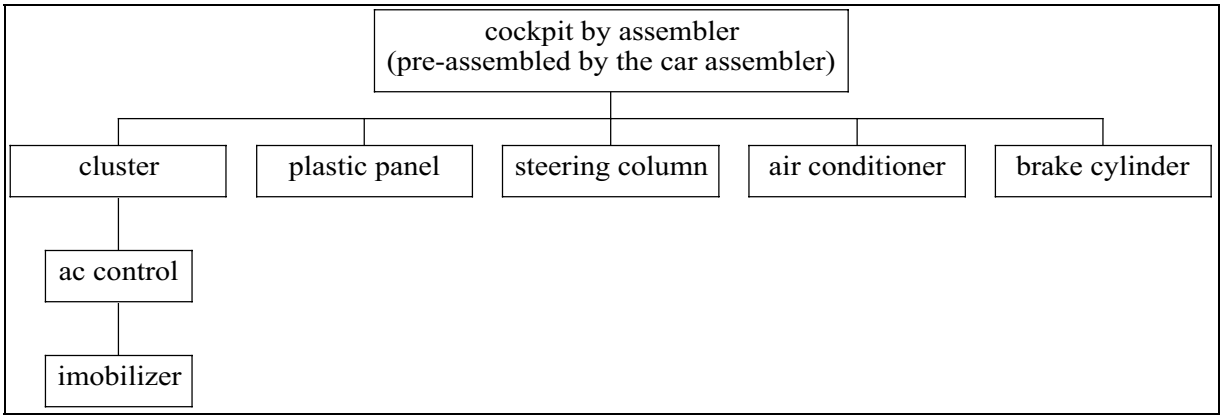
In both cars, the cockpit module has 114 components, that are supplied by approximately 42 companies. The company acting as the systemist in the modular plant (Figure 5) also produces the electronic components and the instruments cluster of the panel.

Figure 5. - *Supply Chain of Cockpit in the Modular Plant*



The only difference is that meanwhile this company is a 'full integrator' in the modular plant, it is simply a Tier 2 supplier in the conventional one (for the car assembler internalized the cockpit assembly), as showed in Figure 6. By full integrator we mean to design the module, to select the Tier 2 suppliers, to make some validation tests, to control quality and to negotiate.

Figure 6. - *Supply Chain of Cockpit in the Conventional Plant*



Considering that outsourcing is related to the supplier participation on design and production, it seems relevant to set differences among the level of supplier's integration. Volpato & Stocchetti [8] referred to the role of first tier suppliers (producers of complex

modules) in this context of more interactions among forms. Authors characterize the information flow as intense, two-way oriented, long-term and electronically integrated by information technologies (EDI and ERP).

The modular plant has higher levels of outsourcing, either in design or in process, than the conventional one. However, even in the modular concept, the idea of co-design was not extended to all modules at the same way. Most systemists are 'manufacturers'; they assumed the assembly of components, while assembler kept on direct contact with Tier 2 suppliers for decisions on the design and production of components. Some of the reasons for that are: the availability of internal capacity (at assembler's plant) to perform design or assembly indoor; the costs (one never know if the suppliers can make less expensive than the assembler) and the expertise of the supplier (sometimes not so evident). Only two systemists are 'full integrators', having shared the design of modules and assumed the development and management of second tier suppliers. These suppliers say that they had many opportunities of learning as they worked with the assembler engineering because the information flow was more intense and frequent.

In the modular one, some of the components suppliers (like the one that makes shock absorbers) received a previous concept of the design and had to develop it themselves. In the conventional plant, the assembler was in charge of all designs, using a 'more prescriptive' dialogue with suppliers who received all information and just applied it.

In respect to the modules, even though a 'manufacturer' supplier does not assume totally the design and commercial activities, it still plays another particular role – to keep the inventory of final products in its own plant. This procedure is quite usual in new plants and even in those restructured where systemists (manufacturers and full integrators) are very close to the final assembly line. That is how the assemblers get to work with few or no inventory by itself and, from the point of view of the systemists, it is not a matter of choice.

CONCLUSION

The study focused on the supply practices used by a car assembly company in both a modular and a conventional plant in order to discuss how the car assembler's choices affect the knowledge transfer in the level of the components production.

The supply system designed for the conventional plant is not directly linked to the product design or to the assembly operation. On the contrary, in the modular plant, it was designed simultaneously with product and assembly process (capacity, arrangements, etc) as a complete package, aiming at major costs reduction. Such target leads to a variety of strategies in which assembler, Tier 1 suppliers and Tier 2 suppliers play different roles either on production, product development and also management of suppliers. As an integrated system, the modular logic demands ability to manage each of the three dimensions and the interface among them. Due to this, the role of each player in the productive chain is not easily changeable – and the risk of building a 'closed package', with no or few flexibility to establish alternative solutions for problems, is really higher.

Comparing the two supply systems from the point of view of the geographical proximity among assembler and suppliers, the modular configuration do favors the contacts and communication inter-firms. But it does not guarantee an open environment for the

information flow. We found that the relationship among suppliers is not so close as it could be, especially in terms of strategic data. For instance, the systemists do not have much more information about the modules produced by other systemists in the modular plant than they have in the conventional configuration. The benefits of proximity seem more intense to the assembler, because of the storage and service issues.

More than modularity, as a consequence of the production system in itself, the level of outsourcing in the modular plant is a major factor for distinguishing between the two plants. The modular one presents a higher level of outsourcing, either during the development of the car or in its production. It was planned to be lean and maybe the outsourcing is the factor that helped most to achieve this goal. Several examples of outsourcing are observed in this case: pre-assembly of several complete modules; pre-processing of raw material; delivery of small components in a special package and in the exact point of use on final line – and all deliveries planned to operate in JIT or JIS basis.

Besides outsourcing, namely the main factor of variance, modularity is also relevant for assemblers, as a way to reduce cost and risk, and especially for a few suppliers who add value as full integrators. The risks of a modular arrangement for all players were discussed by Salerno, Dias and Zilbovicius [9] based on the VW truck plant case - the example of extreme outsourcing approach in Brazilian auto plants. For assemblers, it is risky to become very dependent on suppliers as long as they are exclusive. Suppliers, on their own, share investment on dedicated projects – that increases the risks of the business.

In the case studied, the assembler decided to reduce its dependence on suppliers by acquiring all tools used on production of more value-added components. From the point of view of systemists, this measure diminishes their bargain power and the advantages they would get from the 'modular package' in cases of price negotiation. In this context, modularity is an interesting business for those suppliers who sell not only assembled components but also services like co-design of modules and management of sub-suppliers chain. If it happens, the suppliers keep the cost flow of most components in a black-box basis and have better chances in price negotiation than those suppliers that are simply manufacturers (not designers).

The project of the modules, more than of the car, has determined the conception of the modular supply system by the assembler. As long as a specific part of the car is planned to be assembled and delivered as a whole, the plant, the transport system and the localization of suppliers are defined aiming at cost efficiency of such system. From this point of view, a car produced in the modular approach (it means, the final assembly being supplied with modules that are delivered by suppliers) could not be easily produced in a conventional plant unless several drastic changes were made.

With this comparative study we tried to understand whether the modular plant contributes to the information flow among firms in the supply chain and how it affects the second tier suppliers. From the perspective of modular strategy, we found that the answer is not always yes. In the first tier, the modular supply demands a more efficient flow of information whenever the logic of outsourcing is implemented since the beginning of the product design. It means that the modular configuration may promote the knowledge share with the assembler only if the supplier assumes the design and the manufacturing tasks and if it uses its engineering expertise together with the assembler personnel. But this is not a general rule on first tier because it depends on the kind of relationship established between the

assembler and the supplier, which are based on commercial and technological terms. Such interaction is weaker if first tier supplier just pre-assembles the modules.

Also in the lower tiers we found few evidences of production outsourcing from suppliers and no example of design outsourcing or modularity being implemented. No matter the first tier suppliers are full integrators or simply manufacturers, there is no interest on outsourcing from tier two suppliers. As mentioned before, knowledge transfer is more intense if more activities and responsibilities are shared, otherwise information keeps concentrated indoors. Due to this, the chances of tier two suppliers accessing intangible and more valuable information are rare.

REFERENCES AND NOTES

[1] Starr, M. K. 1965. Modular Production - a New Concept. Harvard Business Review v.43, n. 6 (journal).

[2] Baldwin, C. Y. & Clark, K. B. Sep/Oct 1997. Managing in the Age of Modularity Harvard Business Review, v. 75, n. 5 (journal).

[3] Marx, R., Zilbovicius, M. & Salerno, M. S. 1997 The modular consortium in a new VW truck plant in Brazil: new forms of assembler and supplier relationship. Integrated Manufacturing Systems, 8/5 [1997] 292-298. MCB University Press. (journal)

[4] Sako, M. & Murray, F. 2000. Modules in Design, Production and Use: Implications for the Global Automotive Industry. 8th GERPISA International Colloquium Paris (proceedings).

[5] Arnold, U. 2000 New Dimensions of outsourcing: a combination of transaction cost economics and the core competency concept. European Journal of Purchasing and Supply, v. 6. (journal).

[6] Graziadio, T. 2001. Some Evidences of Technological Changes Associated to Modular Production and Supply in Brazil. 9th GERPISA International Colloquium, Paris (proceedings). www.univ.evry.fr/labos/gerpisa/rencontre/index.html.fr

[7] Dias, A. V. C. 1998 Consórcio Modular e Condomínio Industrial: elementos para análise de novas configurações produtivas na indústria automobilística. São Paulo, Departamento de Engenharia de Produção, Escola Politécnica/USP (thesis).

[8] Gullander, S. & Larsson, A. May 23-26, 2000. Outsourcing and Location. Contribution to the Conference on New Tracks on Swedish Economic Research. Moole (Sweden).

[9] Volpato, G. & Stocchetti, A. (na) Managing Information Flows in Supplier-Customer Relationship: Issues, Methods and Emerging Problems. International Motor Vehicle Program, MIT, Boston. http://imvp.mit.edu/papers/0001/volp-stoc1.pdf.

[10] Salerno M. S., Dias A. V. C. & Zilbovicius, M. 1999. Global sourcing X suppliers' proximity in the new auto plants: logistics and service in industrial condominiums and modular consortiums in Brazil. Managing Operations Networks. Euroma Conference, Venice (proceedings).