Rolling Out a "World Car": Globalization, Outsourcing and Modularity in the Auto Industry

Arnaldo Camuffo

Department of Business Economics and Management
Ca' Foscari University of Venice, Italy
e-mail: camuffo@unive.it

Rolling Out a "World Car": Globalization, Outsourcing and Modularity In the Auto Industry

Arnaldo Camuffo

Department of Business Economics and Management
Ca' Foscari University of Venice, Italy
e-mail: camuffo@unive.it

Abstract

This article presents a case study of the "roll-out" of a "world car" (the Fiat Palio). Based on original fieldwork carried on by the author in 6 countries (Italy, Brazil, Poland, Turkey, Argentina, India), it describes one of the most diverse international strategies in the recent history of the auto industry and represents an interesting terrain for analyzing how, in relationship with globalization, outsourcing and modularity play an increasing role in auto design and manufacturing.

The article addresses the following research questions: 1) Does the "world car" approach represent a sustainable and robust strategy? 2) Is there a relationship between globalization, modularization and outsourcing in the auto industry? 3) Can these concepts be used to map out future developments and transformations in the contracting structure of the auto industry?

This field study shows that producing and selling in many different places a car that involves absolute cross-country identity of interior/exterior design, parts, and quality standards (a "world car") represents an innovative and sustainable strategy. It also highlights that the robustness of this strategy decreases as the international scope and time span of the "global" project increase.

The Fiat Palio story also represents the first in depth analysis of what are, at the firm level, the dynamics that link globalization, outsourcing and modularization in the auto industry. The article confirms that modularization a) is a vaguely defined and ambiguously used term in the auto industry; b) is a broad concept, applicable and applied to a number of systems (product design, manufacturing, work organization, etc.); c) has only recently moved its first steps in auto design and manufacturing.

The embryonic applications of modularity in design, manufacturing and organization reported in this study are used to map out future developments and transformations in the product architectures and organizational architectures of the auto industry.

The article also suggests that, within a global strategy, modularization and outsourcing, though remaining conceptually distinct, tend to become, in practice, increasingly inseparable. The modularization of design, production and organization is intimately related to how, while trying to save costs, reduce risky investment, and manage the institutional constraints deriving from globalization, OEMs and suppliers partition their tasks, defining a new international division of labor.

1. Globalization and the new contracting structure of the auto industry

Globalization is having a major impact on the automotive industry. The demand for autos has changed its international structure. Large existing markets areas like North America, Europe and Japan are mature, with prevalent substitution demand. New demand and market growth is to be expected only in emerging markets like Brazil, India and China and, partly, in countries that are peripheries of large existing market areas like East Europe and Mexico.

This international re-location of auto demand is generating an international re-location of auto manufacturing. In fact, during the '90s, most OEMs have pursued a "produce-where-you sell" strategy, opening up new plants in foreign countries and asking some suppliers to follow them with direct investment.

This happened for a number of reasons.

Firstly, models produced and marketed in North America, Europe and Japan do not always fit emerging markets' customers needs. Secondly, governments of emerging market countries put constraints and incentives on auto trade and manufacturing in order to hinder imports and favor foreign direct investment from large multinational companies. Thirdly, locating operations nearby the target market represents an advantage in terms of marketing, sales and logistics. Fourthly, cross-country cost differentials (especially labor cost), are often so high that they can themselves represent a reason why to locate production abroad.

Within this new framework OEMs and suppliers have re-designed their relationships towards a new situation where: a) suppliers play a larger role in terms of parts' design, technology development and, sometimes, even assembly; and b) OEMs tend to focus their activities, narrowing the scope of the operations they carry on.

More generally, assemblers have employed a series of measures to lower the minimum scale of vehicle assembly plant (Florida and Sturgeon, 1999) in order to reduce investment risk, respond more flexibly to volume changes, speed up models turnover, facilitate equipment upgrading, minimize job impact and social cost in case of crisis. Financial considerations are especially critical given the enormous amount of money required by foreign direct investment strategies and the uncertainty of their rate of return and payback time.

On the whole, globalization has sharpened competition and contributed to shaping a new international division of labor in the auto industry, one where suppliers can achieve economies of scale and of specialization and OEMs can reduce the organizational costs stemming from the complexity underlying international strategies. At the same time, new (especially Internet related) technologies are facilitating knowledge codification (Nonaka and Takeuchi, 1995), reductions in information costs, and evolution towards mass customization and build to order (Helper and Mac Duffie, 2000). These technologies tend to lower the transaction-specific nature of information, knowledge and capabilities, reducing coordination costs for market-type relationships.

Therefore, in the new global auto industry, there have been (and, to a certain extent, there still are) incentives to transfer component design/manufacturing responsibility to suppliers. This has entailed, from the OEM perspective, more outsourcing, and determined a power shift in favor of suppliers (Fine, 1998), as they continue to grow and consolidate in a wave of M&As operations.

But, despite this moving assets off the books to suppliers, designing and managing an international supply chain *remains* a complex task for OEMs. Trying to use e-business tools (B2C and B2B) across the supply chain, facing the different national and regional institutional settings, seeking cost savings in low wage countries and minimizing investment risk, not only imply a different partition of tasks and rights across the supply chain, but also impact on product architecture feeding back into greater product design/technological complexity (Sako and Murray, 1999; Fujimoto and Takeishi, 2001).

Modularization is one possible way to address this issue and reduce complexity. Modularization means that, in the future, vehicles will probably result from the integration of a series of self-contained functional units with standardized interfaces within one or more standardized product architectures, units conceived, manufactured or supplied, and assembled as autonomous "modules" (Helper, MacDuffie, Takeishi and Warburton, 1999).

At the moment, the term “modularity” itself is still somewhat vague in the auto industry. Practitioners (but, to some extent also scholars) are using it to cover a wide variety of practices, whose common elements (and relationship to any core definition) are relatively few. This relates to the fact that a) modularity is a broad concept that can refer to a variety of different systems and variables (product design, manufacturing, work organization, inter-firm relationships, etc.); b) modularization has only recently moved its first steps in the auto industry; and c) the drivers and purposes of modularization are diverse across regions and companies.

2. Working out the “modularity” concept in the auto industry

2.1. Modularity in design

Referring to modularity in product design, Baldwin and Clark (1997, p.86) assert that the decomposition of a system into modules requires three elements:

- An architecture that specifies what modules will be part of the system and what their functions will be.
- Interfaces that describe in detail how the modules will interact, including how they fit together and communicate.

- Standards that test a module's conformity to design rules and measure the module's performance relative to other modules.

Modularity-in-design is therefore defined as choosing the design boundaries of a product and of its components so that design features and tasks are interdependent within and independent across modules (Huang and Kusiak, 1998; Sako and Murray, 1999). In the auto industry, very few companies have advanced very far in the modularization of design and, on the whole, the practices that reflect a relationship to this definition are relatively few. This situation reflects the fact that, both for functional/technological and historical reasons, the current dominant product architecture (Ulrich, 1995) for autos is integral rather than modular, i.e. auto parts present little cross-product/cross-firm standardization.

2.2. Modularity in manufacturing

Modularity-in-production means, instead, choosing product design and plant design boundaries to facilitate production to meet product variety, production flow, cost and quality requirements. Besides, the industry jargon (but also some literature) widens this definition and refers to modular manufacturing also as designing manufacturing and assembly in order to reduce the complexity in the main process by means of sub-assembly, pre-fitment testing of modules, and transferring some of these activities to suppliers (He and Kusiak, 1997; Kinutani, 1997; Fujimoto and Takeishi, 2001).

Apart from the early experiments at GM-Opel and Fiat in the late '80s, in the last five years GM, Ford, Daimler-Chrysler, Mercedes-Benz, Volkswagen and Fiat have experimented with modular assembly plants overseas.

Volkswagen was the first OEM to apply modularity concepts extensively and on an international basis, specifically at its plants in Resende (Brazil), Boleslav (Czech Republic) and Mosel (former East Germany) (Marx and others, 1997).

Notwithstanding the controversial results of these experiments, other automakers have continued to study modular manufacturing, developing production systems in which a) suppliers design, build and deliver major subassemblies, such as a complete front end, a cockpit, a door; and b) OEMs minimize investment and can focus on engineering vehicles, work on quality, and serve customers. The key idea is that having modules made on separate and/or parallel production lines by suppliers makes it easier to change and improve those components, and therefore less likely to cause plant-wide breakdowns. General Motors Corp. and Ford Motor Co. have built modular-style assembly plants in Brazil's southernmost state of Rio Grande do Sul. The Ford plant produces subcompact cars. 12-15 primary suppliers deliver subassemblies from their own factories nearby. The GM plant is similar and equally leads towards a plant significantly smaller, both in terms of size and investment, than others.

In July 1998 Chrysler set up a completely new pick-up truck (the Dakota) factory in Curitiba in the state of Paranà, south of San Paolo. The unique feature of this plant is the outsourcing of the "rolling chassis" to Dana; a US, Ohio based supplier located a few kilometers from the assembly factory. The latter is therefore smaller than usual, allowing Chrysler to reduce its own expenses by lowering stock levels and sharing risks (and presumably profits and losses) with its suppliers.

The financial crises of the late 1990s in the Far East, Mercosur and Russia seem to have added to the growing need to reduce the risks associated with the huge investment required to set up production plants. As a result, the trend toward modularization *and* outsourcing of support and direct activities has continued and will probably continue in the future.

Some OEMs have implemented modular manufacturing in their home country plants, too. General Motors has been most outspoken in its plans to pursue modular manufacturing in North American plants[1]. But Ford Motor Co., DaimlerChrysler AG and others are also adopting modular production methods in their North American and European operations. The most famous example is probably the MCC plant in Hambach (France). MCC is a joint venture between Mercedes Benz and Swatch (Swiss watch producer), that assembles a two-seater “minicar” (named Smart). A small group of suppliers, defined as “system partners”, located nearby the MCC plant, build and deliver complete modules like doors and cockpits directly to MCC final assembly line (Fujimoto and Takeishi, 2001).

Summarizing, in auto manufacturing globalization seems to have triggered a trend toward a change in the dominant configuration of assembly plants and supply relationships (“production architecture”), from the traditional one, that was substantially closed and nonmodular, to a new one, where:

a) production systems are broken down into quasi-independent subsystems (“modules”), which are likely to correspond to design modules (a door, a front end, a cockpit, etc.), and become more standardized initially across plants of the same OEM, and, possibly in the future, across companies, and across OEMs-suppliers relationships; b) plant size tend to be lower than in the past and a handful of “full service” suppliers design, build and deliver larger sets of components either from within the OEM plant (modular consortium) or from satellite plants (supplier park).

2.3. Modularity in organization

Most researchers seem to converge on the idea that there is a relationship between product architecture and organizational architecture (Sanchez and Mahoney, 1996; Langlois, 1999; Baldwin and Clark, 2000; Helper and MacDuffie, 2000; Fujimoto and Takeishi, 2001). However, it is not yet clear how modularization of design and production relates to intra-firm and inter-firm organizational design.

As regards internal organizational design, for example, some research (Tsukune and others, 1993; Rogers and Bottaci, 1997) refers to modular production as designing manufacturing processes in order to flexibly reprogram machining, welding and assembly systems in a timely and cost-effective manner to quickly adjust production output to market conditions. Plants are intended to have greater versatility for future engine or car body changes without extensive retooling or large capital investment. Layout and equipment can be standardized in elementary bundles. In many cases, different plants of the same OEM tend to follow a common technological and organizational template conceived and developed in a "pilot" plant in order to take advantage of a) economies of scale and learning effects, and b) cost effective, timely and easier plant start-ups. From this standpoint the concept of modularity takes up a typical organizational meaning and mingles with those of standardization, scalability and replication. It means that the typical operating processes of a plant are broken down in "modular organizational units" and designed in terms of self-contained units defined as production modules. Each "organizational module" can correspond to a "design module", is characterized by certain equipment and degree of automation (with possible variants and adaptations), follows a given organizational scheme (in terms of staffing, teamwork, number of hierarchical layers, direct/indirect workers ratio, training and performance appraisal procedures, compensation policies, etc.) and is designed to meet required production capacity. A major consequence of this aspect of modularity is the cross-plant "replication" of work organization, human resource management systems, logistics and supplier relationships, in addition to production equipment. Thus, if several plants (even belonging to different OEMs) use the same technology supplier (say for body welding or assembly equipment), and component suppliers are the same for at least part of the process, then working by modules also means repeating in different plants (and, possibly, different companies) an established set of relationships, working methods, standard operating procedures, rules, documentation and communication devices[2].

With modularity in organization, organizational processes, governance structures and contracting procedures could be fine tuned and replicated first of all within firms, i.e. across plants of the same firm in different countries, then between a given OEM and its suppliers, and, eventually, even across firms and supply chains. Especially if the internet technologies will openly support the OEMs-suppliers relationships, these systems of rules and incentives could possibly become one or more organizational standards in the auto industry, facilitating risk sharing in multiple customers/multiple suppliers relationships and allowing transaction cost reductions across the whole supply chain.

Therefore, as regards intra-firm and inter-firm organizational design, an analogical application of modularity to organization, implies that, in general, an organization tend to be modular when interdependence is low between and high within each "organizational" module, guideline that follows the classical principle proposed by Thompson (1967).

It is worth noting that, in the extreme situation in which, for technological reasons, interdependence within is maximum (extremely high) and interdependence between is minimum (extremely low), the standard interface that allows the "organizational modules" to coordinate with one another without communicating large volumes of information is the price system (Langlois, 1999).

The fact that market-type relationships mirror, from a social institutions/organizational perspective, the theoretical situation of perfect modularity in design and production, poses the question of the relationship between outsourcing and modularity.

3. Outsourcing and modularity

The previous section showed that, compared with other sectors, modularization has only recently moved its first steps in the auto industry (Lynch, 1999). Only in the last few years OEMs and suppliers have worked on the idea that an automobile is a complex system that can be broken up into discrete pieces (modules) -which can then communicate with one another through standardized interfaces within a standardized architecture- and that given types and amount of knowledge can be encapsulated within such modules.

Also the fact that, in the auto industry, modularity is a vaguely defined and ambiguously used concept has had a number of effects. For example, while plenty of academic work has concentrated on modular design (Baldwin and Clark, 2000) studying practices from such industries as computers and software, few carmakers have extensively experimented with modularity in product development.

Practitioners are more familiar with modular manufacturing, but, in many cases, OEMs and suppliers use this as a synonym of outsourcing, generating confusion. In fact, outsourcing of various, even direct assembly activities can take place even though there is no modularity in design, sourcing or manufacturing (typical European and US practice). By reverse, modularization can exist without outsourcing (Helper and others, 1999) (typical Japanese practice (Fujimoto and Takeishi, 2001)).

However, although conceptually distinct, outsourcing, task partitioning, standardization and knowledge encapsulation remain strictly intertwined in practice, since the evidence coming from the field shows that, especially within global strategies, modularization and outsourcing are becoming increasingly inseparable, that is suppliers increasingly tend to design, produce (either at their own facilities or somewhere else) and deliver complete modules with standardized interfaces within a given product architecture. The main consequence of this trend is that modularity *and* outsourcing are related to a major transformation of supply chains and organizational forms (Sako and Warburton, 1999). This relationship between the process of task partitioning between OEMs and suppliers and the process of standardization and "knowledge encapsulation", that is typical of modularization, give partial support to what maintained by Sanchez and Mahoney (1996 and 1997), who contend that, while nonmodular products lead to or are best produced by nonmodular organizations, modular products call for modular organizations. Also Langlois (1999) asserts that traditional, bureaucratic firms' organization reflect nonmodular structures, that is a partition of property rights, decision rights, alienation rights, and residual claim of income rights alternative to an atomistic modularization in which all four coincide. Therefore, as in the past (following lean production principles) auto manufacturing moved from the traditional bureaucratic/hierarchical/vertically integrated organization to more flexible network organizations (the Toyota system, the OEMs-suppliers partnership, etc.), in the future, especially if the internet (B2C and B2B) enables mass customization and build to order, it will probably move on to a new model, similar to the "Dell-direct" model in the computer industry (Helper and MacDuffie, 2000), taking the form of turnkey networks (Sturgeon, 1997).

Nonetheless, if it is true that product architecture impacts on organizational architecture, it is also true the reverse. In other words, modularity is not only a cause, but also an effect; modularity, namely modular design, *does not purely and simply determine* organizational structures, but, to a certain extent, it is also a consequence of intra-firm organizational design choices and inter-firm boundary definition strategies, which, in turn, can derive from labor markets or capital markets considerations (Sako and Murray, 1999).

Within this context, globalization plays an increasingly crucial role. As pointed out in section one, since it contributes shaping the international division of labor between OEMs and suppliers, it also has an impact on modularization.

In fact, international rules (trade barriers, local contents, etc.), regional/national institutions, and cross-country cost differentials impact on the transfer of component design/manufacturing responsibility to suppliers and, as a consequence, on the degree of decomposability and information partitioning into visible design rules of new and existing products (Schilling, 2000).

Summarizing, despite the ambiguous terminology, the few experiences realized in the auto industry confirm the link between globalization, outsourcing and modularization, and show that modularization of auto design and manufacturing tend to be a typical feature of international strategies, especially at OEM greenfield plants in emerging regions (Sako and Warburton, 1999). In fact, although modularization had its origin and early development in Europe[3], OEMs tend to experiment with modularity in new/greenfield plants and in foreign/emerging markets (e.g. the Delphi's cockpit module for the US made Mercedes Benz's sport utility car is supplied from a greenfield plant in Alabama) (Sako and Murray, 1999).

4. Research questions and design

This article presents some of the results of a two-year research on the globalization of the Italian automobile industry. The research tried to address the following research questions:

1) Does producing and selling in many different places a car that involves absolute cross-country identity of interior/exterior design, parts, and quality standards (a "world car") represent a sustainable and robust strategy?

2) Is there a relationship between globalization, modularization and outsourcing in the auto industry? What are the dynamics at the firm level that actually link these three factors?

3) Can these concepts be used to map out future developments and transformations in the contracting structure of the auto industry?

The research used the case study methodology, following the guidelines proposed by Ragin and Becker (1992) and King, Keohane and Verba (1994).

Differently from the usual static approach of cross-country and cross-company comparative studies, the key idea was to follow, taking a longitudinal and evolutionary perspective, the “roll-out” of a single model (platform), the Fiat Palio “world car”, reconstructing the whole process from product conception and development (1993) to industrialization and production in 6 plants in 6 countries (1996-2000)[4].

The data presented in the manuscript was collected by the author through plant questionnaires (one for each plant) and extensive interviewing (approximately 150 hrs.) with Fiat managers both at the Italian headquarters and at the different international locations (Cordoba and Buenos Aires, Argentina; Betim and Belo Horizonte, Brazil; Bielsko Biala and Tychy, Poland, Istanbul and Bursa, Turkey; and Mumbai and Ranjangaon, India).

4. The "world car": utopia or reality?

In the new global auto industry OEMs have to manage the trade off between the search for efficiency -that basically derives from achieving economies of scale, increasing standardization, exploiting factor price differentials, and transferring knowledge throughout the organization- and the need to adapt products and processes to the local conditions and the preferences of customers living in countries characterized by diverse structural (mobility, highways, roadways, fuel prices, etc.) and social (available income, level of urbanization, culture etc.) conditions. In doing this, OEMs have followed different patterns (Freyssenet and others, 1998, 1999), and there does not seem to be a unique, dominant, or significantly more successful strategy.

For example, while some auto makers tend to design cars with a common underbody/platform (in order to simplify and standardize manufacturing) articulating and adapting it to a number of markets through a wide array of models, other car makers prefer to customize both models and manufacturing in each country in order to respond to the specific requests of each market, meet the local content requirements, and take advantage of lower "local" costs (both labor and parts).

Differently from these approaches, FIAT has chosen a peculiar strategy, designing a "world car", the *Palio*, that is a family of models (common platform) specifically conceived for big emerging markets. The "world car" concept applies here since on the one hand vehicles are fully standardized all over the world, no matter where they are produced; and on the other hand technology, organizational structures and human resource systems tend to be homogeneous across plants since they share a common concept and thanks to knowledge transfer and internal learning processes.

Global Sourcing (purchasing of parts and modules at the best worldwide conditions in terms of quality, cost and delivery) and *World Material Flow* (logistic process that governs worldwide transactions among Fiat plants and between Fiat and suppliers) support the "world car" concept in the sense that each Fiat Palio should theoretically be the result of the "best" parts and assembly processes, no matter where they are produced[5].

The Fiat *Palio* "world car" concept is different from the experiments (and failures) of the past (e.g. the GM Chevette and Ford Escort projects of the '70s). In fact, on the one hand it is more comprehensive, since it attempts a global optimization of the whole supply chain, but, on the other hand, it refers to a narrow, well-defined market segment, the "popular car" or "family car" aimed at satisfying basic motorization needs. Another difference is represented by the fact that Fiat designed a "world car family" rather than a single "world car"[6].

The Fiat *Palio* "world car" is currently sold in 32 and built in 7 countries.

5. The development of the Fiat *Palio* "world car"

Interestingly, the *Palio* project had started in 1992 as a restyling of the *Uno* model for the Brazilian market. But in 1993 the scope of the project changed drastically and Fiat decided to create a "world car" project (internally named *178*), whose main features were:

1. Define a family of new models targeted to emerging countries motorization needs [7], based on the same platform (5 models with at least 69% of parts in common), to be produced and sold with no significant change, in a number of countries.
2. Create a worldwide supply chain (governed by two management systems, named global sourcing and world material flow) to assembly, in different places of the world, that family of new models.
3. Guarantee absolute cross-country standardization of each version of the models produced, even if they are targeted to different national markets.

The development of *Palio* came to its crucial stage in the summer of 1993. At that point a "platform-based" organizational unit (more than 200 people), involving an external engineering company -IDEA Institute- was set up for style development. Outsourcing of engineering was heavy and amounted to 80% of total design costs. The platform unit consisted of 12 module-based teams (engine, suspensions, seats, doors, cockpit, etc.) composed of engineers and ttechnicians detached from Fiat central departments, foreign operations and key suppliers.

5.1. Rolling out *Palio* in Fiat foreign plants

Table 1 summarizes the international scope of the *Palio* "world car" project. The production of *Palio* started at the Betim plant in Minas Gerais, Brazil, in January 1996. Argentina followed suit in December 1996 after difficult negotiations about re-starting activity in the country and the building of a new plant in only eighteen months at Cordoba. Fiat Auto Poland plant in Bielsko-Biala began assembling *Siena* and *Palio* SW in March 1997[8]. In Morocco, production of Siena and Palio started in autumn 1997 and June 1998 respectively, by the Moroccan company Somaca, which works as a *façonist*[9]. In Turkey, Fiat TOFAS plant in Bursa started production of *Palio* hatchback and SW in March 1998[10].

In January 1998 Fiat Auto defined an agreement through Fiat Auto South Africa with Nissan South Africa, which owns a plant in Rosslyn. Nissan carries out the assembly of Siena, Palio, Palio SW and Strada pick-up models. In India[11], Fiat started producing *Siena* in April 2000.

Fiat reached a cumulative production of one million units of *Palio* vehicles in May 1999. This was below than expected, since the South America economic slump slew down operations.

Table 1

Fiat has plans to bring *Palio* also in China and Russia as soon as market an international conditions allows such a commitment.

5.2. Understanding how *Palio* is made in the different plants

The Fiat *Palio* "world car" project is an interesting terrain for understanding what are, at the firm level, the dynamics that link globalization, outsourcing and modularization in the auto industry.

It must be noted that modularization does not take place in a vacuum. Rather, modular products and modular manufacturing overlap and intertwine with existing nonmodular products and plants.

Modularization is therefore the consequence of complex experimental processes, where learning develops, within and between OEMs and suppliers, from trials and errors, even unintentionally and indirectly (Helper, MacDuffie and Sabel, 2000).

As well as attempting to introduce a truly global product, Fiat proposed the *Fabbrica Integrata* as a reference paradigm for homogenizing manufacturing. The former had originally been tested at the Melfi "mother" plant and was re-produced in the form of technological and organizational “modules” in the various foreign plants[12]. At the same time, however, some adaptation to local conditions and to existing products and processes was required. As a result, the plants where the *Palio* is made are different and reflect their historical background and local/national context[13].

Nevertheless, the technological/organizational “modules” in the various Fiat foreign plants do bear a close resemblance to each other. This can be seen in terms of both manufacturing systems ("production modules" of 400 vehicles a day that can be "downgraded" to 200) and organizational structures (units’ boundaries, teams, number of hierarchical layers, work organization, contingent compensation schemes, etc.). For example, the basic organizational units (called UTE *–unità tecnologica elementare)*, managed by a work team, though different in size across each plant’s workshop, tend to be homogeneous across the various plants. Even the internal composition of the teams is similar across the plants, reflecting the basic rules of the *Fabbrica Integrata* (for example, the ratio of semi-skilled to skilled workers, is fairly homogenous, between 1/10 –body welding- and 1/15 –final assembly).

Also the level of automation is homogeneous and mainly low throughout the plants, with the exception of specific applications in brownfield plants, usually deriving from past investments. Most operations are carried out manually, especially in final assembly. The few six axle robots (body welding and assembly) or multiwelders (body welding) are mainly used for older models.

Table 2 compares the level of automation for body welding of *Palio* project models in five plants. It shows the number of automatic welding points as a percentage of the total number. Cross the foreign plants where Palio is made the level of automation is homogeneous and relatively low (below 8%), compared with other Italian plants, like Melfi (approximately 100%).

Table 2

This situation is the result of a number of factors:

1. There is a comparable advantage in not making large-scale investments in automation in countries with low labor costs;
2. Larger plants (such as Brazil and Turkey), are also the oldest ones, with the heaviest investment in automation (but the *Palio* production lines have low degrees of automation).
3. More recent plants are "lighter". They are the result of modular principles and the need to limit investment in the face of very high risks.

These last two points are also related to the attempt to avoid the excesses of "technological lust" (Camuffo and Volpato, 1996) typical of some European and American producers in the 80's (including Fiat) and to focus investment on simple and flexible automation solutions rather than rigid ones (MacDuffie and Pil, 1997). Automation in the assembly shops centers on the installation of the front and rear windscreens (see Table 3). In Brazil this operation takes place through the use of six-axle robots, but it is also done automatically or semi-automatically (e.g. in Poland) in the other three poles. The other main assembly operations considered (wheel to axle fitting, suspension installation, decking and inserting of the spare wheel) are all carried out manually in Brazil, Argentina and Poland. In Turkey the first three operations are done semi-automatically.

Table 3

The time cycle is around two minutes in both Argentina and Turkey despite the greater number of automated operations at Tofas. In the Polish plant of Bielsko Biala, however, the figure is nearly three and a half minutes. These figures confirm that work organization is the variable that has adapted the most to local conditions in terms of labor relations, social variables and culture.

This cross-plant homogenization and modularization of plant technology and organization is associated with an increase in outsourcing, basically absent in the analyzed plants before the introduction of *Palio*.

For example, table 4 shows the degree of outsourcing in body welding. In Brazil an external supplier is responsible for 400 out of 4100 welding points (9.8% of the total) on the Palio. In Poland, almost 600 welding points on the Palio Weekend and Siena have been outsourced. In Turkey, on the other hand, all welding activities are still carried out in-house. Interestingly enough, outsourcing has touched also the press shops. For example, in the Betim plant, Fiat reduced the number of presses leasing the smaller ones (i.e. less than 600 tons) to external suppliers for the production of small panels.

Table 4

The relationship between globalization, the transfer of component design/manufacturing responsibility to suppliers and modularization clearly emerges also from the management of logistics and suppliers at the plant level (table 5).

Table 5

One of the main features of all the plants where the *Palio* is made, is the setting aside of an area close to the plant for the re-location of supplier-partners (supplier park).

This area follows the standard set by the Melfi "mother" plant. It can be found in all the factories except Turkey. However, while Brazil and Argentina use synchronous kanban and just-in -time as modern supply systems, the Turkish and the Polish plants only use just-in-time for a few components.

Poland and Argentina use an external operator to manage the consolidation center at the entrance to the plant. This operator is responsible for transporting, moving and sequencing materials. In the other two poles there is nothing resembling a consolidation center and Tofas manages its own logistic operations.

The number of suppliers for each plant is also of interest. The international tendency, including Fiat's, is to concentrate purchases among a limited number of suppliers, and this is coherent with modularization.

Two other elements are of particular significance: an increase in the number of suppliers located close to the Fiat plant and the growth of the same supplier in several poles. The available data confirms this trend, which is positively related with modularization (Sako and Murray, 1999). Referring to 1997 and 1998, the data in table 6 shows an overall decrease in the number of suppliers and an increase in the number of suppliers with plants located close to the Fiat plants where *Palio* is made. It is also worth noting that the approximately 100 "global" suppliers with multiple locations close to Fiat plants account for about 70% of overall Fiat *Palio*' purchasing volumes. Suppliers' proximity to the OEM assembly plant is also coherent with increasing modularization (sub-assembly supplies with high degree of "knowledge encapsulation" and high logistic costs)[14].

Table 6

6. Modularization and outsourcing in the *Palio* case

As before mentioned, Fiat pioneered a few aspects of modularity in the *Palio* product design process. Even though it cannot be considered neither an advanced nor a benchmarking example of modular design (especially if compared with other industry practices), this experiment is nevertheless remarkable since it took place in 1993, when no relevant trend towards modularity had emerged in the auto industry, yet.

Modularity-in-production has significantly characterized the way *Palio* is made in the different plants from two different perspectives.

Firstly, the degree of modularity-in-production reflects the degree of modularity-in-design. Hence, the little elements of modular design experimented in the *Palio* development process, were partly implemented in the different plants where *Palio* is made. The field research coherently shows that modularity-in-production, from this perspective, is only at an experimental phase (e.g. the cockpit module in Argentina), and that the advancement of Fiat plants towards modular manufacturing is extremely varied and dependent on local factors[15]. The greenfield plant in Cordoba adopted certain aspects of modular manufacturing most quickly. Evolution has been slower and more controversial in Brazil, Poland and particularly Turkey (these are all brownfield plants, dating back several decades, and frequently subject to re-structuring and modernization programs). The Indian plant in Ranjangaon (Pune), originally designed as the greenfield pilot of modular manufacturing principles, is currently in a stand-by situation[16].

Secondly, the field study on Fiat *Palio* confirms that the increasingly widespread practice of outsourcing in foreign plants is associated with modularity-in-production, whiche then feeds back into modularity-in design.

Fiat has worked a lot on outsourcing, that recently interested, both in domestic and foreign operations, the following areas:

1. Logistics, both internal and external. In 1998, Fiat outsourced the whole internal logistic process, including all technical hardware and over 2,000 people, to an external operator, TNT. This was a wholesale transfer of logistic activities, including the transfer of Fiat employees to TNT.
2. Plant and machinery maintenance. Fiat has drawn up a plant efficiency maintenance contract with technology supplier Comau. Since only the latter has the required level of know-how, machinery purchases are accompanied by a service contract. This has led to the creation of Global Service, a third party company affiliated to Comau, which is responsible for maintenance services and employs nearly 2,000 people.
3. Accounting and reporting (incorporation of GESCO)
4. Energy and Ecology
5. Data processing

Even more interestingly, outsourcing has touched also parts of the production process. In some paint shops, for example, suppliers are taking on a increasingly larger role, and such a new task partition between the OEM and its suppliers tend to affect also how knowledge is partitioned between them. PPG, that once only supplied the raw material, now is responsible for the paint-mix center, and, in the future, will probably paint the car bodies itself, using its own staffs and paints. At that final stage (modular painting), the supplier will be fully responsible for designing and operating the process, and Fiat will pay it for each painted body (after it has passed the quality control checks), rather than for the amount of paint consumed. This is producing significant results, such as improved quality, the recouping of unused of paint and reduced overall volumes of paints used. In the brownfield plant at Kurla-Mumbai (in the Maharashtra state of Southwest India), the body welding shop for *Palio* was completely restructured and it is currently run by TurinAuto ITCA, the technology supplier, employing Fiat India people.

On the whole, in the *Palio* project Fiat has outsourced a lot, partly in order to reduce cost, partly in order to minimize investment risk and partly to fulfill institutional constraints (local content). This re-definition of responsibilities between the OEM and the suppliers feeds back into product design architecture, affecting knowledge partitioning between the OEM and its suppliers and possibly enabling modularity in design.

Coming to modularity in organization, with regard to intra-firm organizational design, the roll out of *Palio* in foreign plants followed a common technological and organizational template, exported and replicated in the different countries. As already mentioned before, each Technological/organizational “module” was characterized by certain equipment and degree of automation (with possible variants and potential adaptation), and was organized to meet a given production capacity, which is 400 vehicles per two-shift day. The most notable feature here is that it is possible to put a second identical module parallel to the first, raising production capacity to eight hundred, or even a third raising it to one thousand two hundred, and so on. This is a key point because this application of modularity to production equipment allowed to lower the minimum scale of vehicle assembly plant, to reduce the risk of investment, to respond more flexibly to volume changes, to adapt quickly to models turnover and to minimize job impact and social cost in case of crisis. This approach entails also the "replication" of organizational structures, work organization and human resource management systems.

As regards inter-firm organizational design, this embryonic experiment of modularity in organization touched logistics and supplier relationships management. In fact, if each plant uses the same technology supplier and component suppliers are the same for at least part of the process, then working by modules means repeating in different plants an established set of relationships, working methods, standard operating procedures, rules and communication and documentation procedures.

An optimal "module" of four hundred vehicles was replicated for every Operating Unit in each of the *Palio* project foreign plants, with the exception of India (brownfield plant in Kurla, Mumbai, in the Maharashtra state of Southwest India). Here, demand expectations and labor costs suggested a module adaptation and downsizing (characterized by partly different machinery and a lower level of automation) leading to a "degraded" module with a capacity of two hundred vehicles.

On the whole, there are two main advantages here. Firstly, the technology supplier for body in white (Comau), having design and constructed the first module, can re-apply this to each plant and therefore amortize technology design costs; this implies one-off setting-up costs, since all subsequent start-ups are based on previous experience and are consequently quicker to implement (even for a different client). Secondly, the workforce in the different plants uses the same methods; this directly stems from modularization that allows standard work cycles to be adopted in every plant, leading to similar factory organization. In fact, FIAT has adopted standard working time cycles and a common work organization method, called TMC (*Tempo dei Movimenti Collegati*, and its upgraded version TMC2 consists of breaking down each task into a series of five basic movements and defining the time necessary for each)[17].

To sum up, there are several important advantages linked to this embryonic application of modularity-in-organization ideas:

1. it allows technology design and development costs to be amortized through repeat economies;

2. it allows know-how to be accumulated and used in every new venture, by replicating the same organizational concepts and working methods;

3. it allows production capacity to be increased simply by reproducing the same module in parallel;

4. it allows standard working practices to be defined for all process, service and sub-assembly suppliers.

Another main consequence of the rise of outsourcing in design, technology and production is the increasing number of "external" actors involved in product design, supply, logistics and manufacturing. As a result, organizational boundaries blur, organizational structures change, and the problem of what is the role of the OEMs and how they should manage the various players inevitably arises.

In its foreign and domestic operations, Fiat is responsible for governing the whole system. At the same time, it needs to give suppliers sufficient autonomy to allow them to remain as independently run ventures with their own risk capital. With outsourcing, the aligning of responsibility is even more important in guaranteeing the proper working of open, cross-company, inter-functional teams. The governance system, therefore, requires Fiat to arrange and co-ordinate partner suppliers as it would a team.

This is particularly critical in foreign operations, where, despite the fact that the relationships with some key global supplier can be governed on a global basis, local actors play an important role and usually add on organizational complexity.

To sum up, the transfer of component design/manufacturing responsibility to suppliers in a global context implies not only a different partition of tasks between OEMs and suppliers, but also a different partition of knowledge, and of decision, alienation, and residual claim of income rights among actors (and a related set of rules and contracts with third parties) that could work not only as a cross-plant (and cross-country) common template, but, in the future, also as a cross-firm organizational standard (modularity-in-organization).

7. Conclusion

The Fiat *Palio* "world car" project represents one of the most original and "diverse" international strategies in the recent history of the auto industry. The case study has shown that producing and selling in many different places a car that involves absolute cross-country identity of interior/exterior design, parts, and quality standards (a "world car") represents an innovative, sustainable strategy, based on a systematic, though non-linear, cross-plant and cross-country knowledge transfer process.

Nevertheless, the case study also highlights that the robustness of this strategy decreases as the international scope and time span of the “global” project increase. In the Fiat *Palio* case, in fact, the project complexity a) tremendously increased as it began touching significantly different countries, like India; b) required product customization and conspicuous local adjustment in technologies, organizational structures and management practices, especially in existing, brownfield plants.

It is early to assess how successful the Fiat *Palio* has been. On the whole, the financial performance was initially excellent (1996-1998), and then followed the different market trends, with relevant problems in India, where the "world car" approach did not prove to be completely robust.

There, in fact, the strong commitment to global optimization and cross-country standardization has been challenged by the peculiarities of local competition, institutional constraints and cost factors. For example, local content constraints and tough price competition by other local and global OEMs (Tata, Daewoo, Ford, etc.) have pushed Fiat managers toward a major customization and nationalization of *Siena*.

The Indian market is also interesting in order to fully evaluate the relationship between globalization, outsourcing and modularity in auto design and manufacturing. For example, in the Indian market the Daewoo Matiz competes with Palio; but that model was designed by Giugiaro –the famous Italian auto designer- and originally proposed to FIAT 5 years ago. Moreover, as already mentioned, IDEA Institute designed and engineered *Palio*. But IDEA Institute has recently designed also the Tata Indica (Indian national car related to the Swadeshi concept), a successful car launched in 1999 which strikingly looks like *Palio* (which Fiat has eventually launched in the Indian market only in 2001).

The Fiat *Palio* case study provides an example of what are, at the firm level, the dynamics that link globalization, outsourcing and modularization in the auto industry. It also confirms that there is a relationship between the new international division of labor across the auto industry (stemming from a different task partitioning between OEMs and suppliers) and the process of standardization and "knowledge encapsulation" that is typical of modularization.

The embryonic applications of modularity in design, manufacturing and organization reported in the previous sections can be used to map out future developments and transformations in the contracting structure of the auto industry.

For example, if the internet (B2C and B2B) enables mass customization and build to order, it is likely that the dominant product architecture for autos will become more modular and open (cross-product and cross-firm standardization of components with standardized interfaces), and the transition toward the "turnkey network" (Sturgeon, 1999) or "Dell-direct" (Helper and MacDuffie, 2000) model, almost automatic. But even though the dominant product architecture for autos remains nonmodular, some major transformation is likely to take place. More and more frequently, global suppliers will be able and willing to design modules from proprietary knowledge, manufacturing and supplying them, from their international plants, to multiple customers (OEMs) that want or have to share, at least in part, an increasingly similar product architecture. A good example of this is represented by the recent initiatives of the GM-Fiat powertrain and worldwide purchasing joint ventures. These are intended to develop common, cross-product and cross-firm power trains and components, at the moment for FIAT and GM, but, in the future, also for other OEMs.

From this standpoint, outsourcing and modularity, though increasingly inseparable and overlapped in practice, remain conceptually distinct; for example, OEMs will be interested in transferring to independent suppliers the information required to design and/or produce a given module; but, at the same time, they will be interested also in maintaining, protecting and defending all that knowledge (and, increasingly, it will be architectural knowledge) that represents a distinctive asset (MacDuffie and Helper, 1999), or where there area advantages related to cross-country/cross-firm factor price differentiation (capital and labor market conditions) (Sako and Murray, 1999). Hence, the contracts' format and the related sets of rules and incentives, necessary to design and manage the relationships with suppliers of engineering, components and services, could be standardized not only worldwide across plants (i.e. within the same OEM-supplier relationship, as shown by the Fiat *Palio* case study), but also across supply chains (multiple OEM-supplier relationships).

For some time the term "modularity" will still remain ambiguous in the auto industry, and practitioners (but, to some extent also scholars) will use it to cover a wide variety of practices. But this reflects the fact that a) modularization is a complex, slow and controversial process (for example because it will negatively affect OEMs' capability to differentiate and characterize their vehicles' and brand identity *vis a vis* competitors); b) modularization can refer to different systems and variables (product design, technology, manufacturing equipment, work organization, etc.); and c) auto design and manufacturing is intrinsically more complex than other products like, for example, software or computers (e.g. in terms of logistics, safety and environmental issues).

On the whole, the Fiat *Palio* story confirms that the wave of transformation that has reshaped other, "faster clockspeed" industries (Fine, 1998), is tremendously changing also the contracting structure of the auto industry, and that globalization, together with information and communication technologies, is challenging OEMs' and suppliers' existing strategies and structures.

References

Baldwin C. Y, Clark K.B., (2000), *Design Rules. The power of modularity*, Cambridge, MA, MIT Press.

Baldwin C.Y., Clark K.B., (1997), "Managing in an age of modularity", *Harvard Business Review*, 75 (5):84-93 (September-October).

Camuffo A., Volpato G. (1995), "The Labor Relations Heritage and Lean Manufacturing at Fiat", *International Journal of Human Resource Management*, vol.6, n.4, pp.795-824.

Camuffo A., Volpato G. (1996), "Dynamic Capabilities and Manufacturing Automation: Organizational Learning in the Italian Automobile Industry", *Industrial and Corporate Change*, Vol.5, n.3, pp.813-837.

Fine C. (1998), *Clockspeed: Winning Industry Control in the Age of temporary Advantage*, Boston, Perseus Books Publishing.

Freyssenet M., Mair A., Shimizu K., Volpato G. (eds.) (1998), *One Best Way? Trajectories and Industrial Models of the World's Automobile Producers*, Oxford University Press, Oxford.

Freyssenet M., Shimizu K., Volpato G. (eds.), (1999), *Internationalization Strategies and Trajectories of Automobile Firms*, London, McMillan.

He D., Kusiak A., (1997), Design of Assembly Systems for Modular Products, *IEEE Transactions on Robotics and Automation*, Vol. 13, No. 5, pp. 646-655.

Helper S., MacDuffie J.P, (2000), E-volving the auto industry: E-business effects on Consumer and Supplier Relationships, paper prepared for E-business and the Changing Terms of Competition: A View From Within the Sectors, The Fischer Center on the Strategic Use of Information Technology, Haas School of Business, UC Berkeley, December.

Helper S., MacDuffie J.P, Pil F., Sako M., Takeishi A., and Warburton M., (1999), "Project Report: Modularization and Outsourcing: Implications for the Future of Automotive Assembly", paper prepared for the IMVP Annual Forum, MIT, Boston, 6-7 October.

Helper S., MacDuffie J.P., Sabel C., (1999), "Pragmatic collaborations: advancing knowledge while controlling opportunism", *Industrial and Corporate Change*, Volume 9, Issue 3, pp. 443-488.

Huang C.C., Kusiak A., (1998), Modularity in Design of Products and Systems, *IEEE Transactions on Systems, Man, and Cybernetics*, Part A, Vol. 28, No.1, pp. 66-77.

King G., Keohane R., Verba S., (1994), *Designing Social Inquiry*, Pronceton, NJ, Princeton University Press.

Kinutani H., (1997), "Modular assembly in mix-model production at Mazda", in Fujimoto T., Shimokawa K., Juergens U., (eds), (1997), *Transforming Auto Assembly. International experiences with automation and work organization*, Frankfurt, Springer Verlag.

Fujimoto, T., Takeishi A., (2001), Modularization in the Auto Industry: Interlinked Multiple Hierarchies of Product, Production and Suppliers Systems, CIRJE-F-107 discussion paper, Tokyo University, March.

Kusiak A., Huang C.C., (1996), Development of Modular Products, *IEEE Transactions on Components, Packaging, and Manufacturing Technology - Part A*, Vol. 19, No. 4, pp. 523-538.

Langlois R. N., (1999), Modularity in Technology, Organization and Society, paper presented at the conference on "Austrian Economics and the Theory of the Firm", Copenhagen Business School, August, 16-17.

Lynch T.M., (1999), "Globalization in the Motor Vehicle Industry: Final Conference Summary", MIT-IPC Working Paper #98-0010, January.

MacDuffie J.P., Helper S. (1999), "Creating lean suppliers: diffusing lean production through the supply chain", in Liker J., Adler P., Fruin M (eds.), *Remade in America: Transplanting and transforming Japanese Production Systems*, Oxford University Press, New York.

MacDuffie J.P., Pil, F., (1997), "Flexible technologies, flexible workers", in Fujimoto T., Shimokawa K., Juergens U., (eds), (1997), *Transforming Auto Assembly. International experiences with automation and work organization*, Frankfurt, Springer Verlag.

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*, n.5.

Meyer M.H., Lehnerd A.P. (1997), *The Power of Product Platforms – Building Value and Cost Leadership*, The Free Press, New York.

Nonaka I., Takeuchi H., (1995), *The knowledge creating company*, Cambridge, Oxford University Press.

Ragin C., Becker H., (eds.), (1992), *What is a Case? Exploring the Foundations of Social Inquiry*, Cambridge, MA, Cambridge University Press.

Rogers G.G., Bottaci L. (1997), "Modular Production Systems: A New manufacturing Paradigm", *International Journal of Intelligent manufacturing*, Vol.8, n.2, 147-156.

Sako M., Murray F., (1999), "Modules in Design, Production and Use: Implications for the Global Automotive Industry", paper prepared for the IMVP Annual Forum, MIT, Boston, 6-7 October.

Sako M., Warburton M., (1999), "Modularization and Outsourcing Project. Preliminary Report of the European Research Team", paper prepared for the IMVP Annual Forum, MIT, Boston, 6-7 October.

Sanchez R., Mahoney J.T. (1996), "Modularity, flexibility and knowledge management in product and organization design", in *Strategic Management Journal*, vol. 17, Winter Special Issue, pp. 63-76.

Sanchez R., Mahoney J.T., (1997), "Modularity, Flexibility, and Knowledge Management in Product and Organizational Design", *IEEE Engineering Manaagement Review*, pp. 50-61.

Schilling M.A. (2000). “Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity”, *Academy of Management Review*, vol. 25, no. 2, pp. 312-334.

Sturgeon T. (1997), "Turnkey production networks: A new American model of Industrial Organization?", BRIE working paper 92A, University of Berkeley, August.

Sturgeon T. and Florida R. (1999), The World that Changed the Machine: Globalization and Jobs in the Automotive Industry, International Motor Vehicle Program – MIT Globalization Research.

Thompson, J.D., (1967). *Organizations in Action*. New York: McGraw-Hill

Tsukune H., Tsukamoto M., Matsushita T., Tomita F., Okada K., Ogasawara T., Takase K., Yuba T., (1993), Modular Manufacturing, *International Journal of Intelligent Manufacturing*, Vol. 4, No. 2, pp. 163-181.

Ulrich K., (1995), “The Role of product Architecture in the manufacturing Firm”, *Research Policy*, vol.24, pp. 419-440.

Country	Company	Production Capacity	Models	Investment (Mln $)	Start-up	Current status
Brazil	Fiat Automovéis (FIASA)	391.000	Palio, Palio WE, Strada	560	gen-96	In progress
Argentina	Fiat Argentina (FAA)	127.000	Palio, Siena	180	dic-96	In progress
Venezuela	Fiat Automoviles (FAV)	20.000	Palio, Siena	5	mar-97	Stopped
Poland	Fiat Auto Poland (FAP)	46.000	Siena, Palio WE	70	mag-97	In progress
Morocco	Fiat Auto Maroc (FAM)*	24.000	Palio, Siena	30	set-97	In progress
Turkey	TOFAS (joint-venture with Koc Group)	114.000	Palio, Siena, Palio WE	165	mar-98	In progress
India	Fiat India Auto Limited (FIAL)	85.000	Palio, Siena, Palio WE	220	mar-99 (Siena); 2000 (Palio WE); 2001 (Palio)	In progress
Russia	Nizhegorod Motors (joint-venture with Gaz)	Not available	Palio, Palio WE	Not available	Not available	Delayed
Egypt	Fiat Auto Egypt (joint-venture with il Seoudi Group)**	20.000	Siena	10	feb-00	In progress
South Africa	Fiat Auto South Africa (FASA)***	30.000	Palio, Siena, Palio WE, Strada	50	feb-00	In progress
China	Nanya Co. (joint-venture with Yuejin Group)	Not available	Palio, Palio WE, Siena	Not available	2001	Delayed

notes
* SOMACA works as a façonist
**:Seoudi Group (Nissan Egypt) works as a façonist
***: Nissan Soth Africa works as a façonist

Table 1 - International scope of Fiat Palio "world car" project.

	Body welding operating units					
Plant	**MELFI ITALY**	**BETIM BRAZIL**	**CORDOBA ARGENTINA**	**BIELSKO BIALA POLAND**	**BURSA TURKEY**	**KURLA INDIA**
Degree of automation* = number of automatic welding points as a percentage of the total**	**100%**	**1%**	**5.7%**	**0%**	**7.7%**	**0%**

*The figures refer to the Palio hatchback (about 3500 welding points overall) with the exception of Bielsko Biala, where the figures refer to the Siena and Melfi, where the figures refers to Punto (about 4000 welding points overall).
**Automatic welding points are those given by robots.

Table 2 - Degree of automation for body welding of Fiat Palio platform models in 6 FIAT plants

	FINAL ASSEMBLY OPERATING UNIT					
Final assembly direct operation*	**MELFI ITALY**	**BETIM BRAZIL**	**CORDOBA ARGENTINA**	**KURLA INDIA**	**BIELSKO BIALA POLAND**	**BURSA TURKEY**
Installation of front windscreen and sealer	**Robot (6 axle)**	**Robot (6 axle)**	**Rigid Automation**	**Manual**	**Manual Assisted by automation**	**Rigid Automation**
Installation of rear windscreen and sealer	**Robot (6 axle)**	**Robot (6 axle)**	**Rigid Automation**	**Manual Assisted by automation**	**Manual Assisted by automation**	**Rigid Automation**
Fitting of wheel to axle shaft	**Manual Assisted by automation**	**Manual**	**Manual**	**Manual**	**Manual**	**Manual Assisted by automation**
Inserting of suspension	**Manual Assisted by automation**	**Manual**	**Manual**	**Manual Assisted by automation**	**Manual**	**Manual Assisted by automation**
Fitting of engine to body	**Robot (6 axle)**	**Manual**	**Manual**	**Manual**	**Manual**	**Manual Assisted by automation**
Inserting of spare wheel	**Manual Assisted by automation**	**Manual**	**Manual**	**Manual**	**Manual**	**Manual**

*The data refers to assembly lines handling various Palio vehicles; for the Melfi plant, the data refers to Punto.

Table 3 - Degree of automation and methods used in several typical final assembly operations in 6 Fiat plants.

Welding spots on Palio platform models	**Brazil**	**Argentina**	**Poland***	**India***	**Turkey**
Applied internally	**3.700** **90,2%**	**3.238** **n.a.**	**3.554** **85,6%**	**1488** **100%**	**4.287** **100%**
Outsourced	**400** **9,8%**	**n.a.** **n.a.**	**600** **14,4%**	**None**	**None**
Total	**4.100**	**n.a.**	**4.154**	**1488****	**4.287**

* The figures refer to the Siena model since the Palio hatchback is not produced.
** This data is significantly lower than the others because of the different nature of metal panels and press work. The body welding shop is fully managed by ITCA, a technology supplier.

Table 4 - Number and percentage of internally applied and outsourced welding points in 5 FIAT Palio project plants.

	SUPPLIER AND LOGISTIC MANAGEMENT				
PLANT	**BETIM BRAZIL**	**CORDOBA ARGENTINA**	**BIELSKO BIALA POLAND**	**BURSA TURKEY**	**KURLA INDIA**
SUPPLIER AREA	**YES**	**YES**	**YES (Tychy)**	**NO**	**NO**
CONSOLIDATION CENTRE	**NO**	**YES (Cargo)**	**YES (TNT)**	**NO**	**NO**
EXTERNAL LOGISTICS OPERATOR	**TNT (transport and packaging of outgoing materials)**	**Cargo (transport and handling of line materials)**	**TNT (External transport and handling of line materials)**	**NO**	**NO**
UTE LEVEL MANAGEMENT OF SUPPLIERS	**NO**	**YES**	**NO**	**NO**	**NO**
NUMBER OF SUPPLIERS	**174**	**140**	**346**	**196**	**125**
DEGREE OF NATIONALIZATION (% supplies value)	**96%**	**55% (85% from Mercosur)**	**60%**	**70%**	**60%**
OUTSOURCED ACTIVITY	**ACCOUNTING PLANT MAINTENANCE**	**ACCOUNTING PLANT MAINTENANCE LOGISTICS PAINT CENTRE**	**ACCOUNTING PLANT MAINTENANCE LOGISTICS PAINT CENTRE SHEET METAL WORKING**	**NONE**	**BODY WELDING SHOP**

Table 5 - Logistic and supplier management in 5 FIAT Palio project plants

Year		**International FIAT suppliers and production poles**					**Total FIAT suppliers**
		Suppliers present in 1 pole	*Suppliers present in 2 poles*	*Suppliers present in 3 poles*	*Suppliers present in 4 poles*	*Suppliers present in 5 poles*	
1997	Number	903	63	17	14	6	1003
	%	90%	6,3%	1,7%	1,4%	0,6%	100%
1998	Number	766	55	19	16	10	866
	%	88,4%	6,4%	2,2%	1,8%	1,2%	100%

Table 6 Fiat Palio s*uppliers globalisation*

Endnotes

[1] The GM's Project Yellowstone, which the company has presented as the next-generation model for modular manufacturing of its small cars, is interesting the factories in Lansing and in Lordstown, Ohio, where GM hopes to build a new generation of small cars in the plant starting in 2002.

[2] This practice of following a common organizational template has been recently used also by General Motors (the GMT-800 platform) which the company is attempting to build with standardized work practices across seven plants and three unions in Canada, the United States and Mexico

[3] Interestingly, Fiat was a leader and a pioneer in the use of modules. In the late '80s, the Italian OEM experimented modularity in its *Tipo* platform at the Cassino (South Italy) plant, trying to simplify the car's design and assembly, reduce the capital equipment and facilities required, optimize component sharing across models stemming from the same platform.

[4] To tell the truth, as pointed out in section five, Palio is currently made, out of CKDs, also in Morocco, Venezuela and South Africa. For simplicity, the article does not fully report on these operations.

[5] The international supply chain supporting this globalization process can be interpreted as a double network of operations and transactions: the "internal" supply chain, where "makes" are exchanged between Fiat Auto plants; the "external" supply chain where "buys" are purchased by Fiat Auto plants from suppliers. In the "external" supply chain, Fiat Auto manages, in a global sourcing perspective, a relatively stable group of suppliers, though in a competitive perspective, in order to guarantee cross-plant and cross-market component uniformity and worldwide efficiency. Fiat's global outsourcing model aims at finding suppliers offering the best combination of costs, quality and service worldwide, standardizing all the parts of *Palio* in every production and assembly plant. This model is centrally managed and puts competitive pressure on suppliers by means of worldwide comparisons on suppliers' prices, quality and service.

[6] In the internal jargon, *Progetto 178* is the code name of the world car project that identifies the vehicles stemming from the same platform: a three-door hatchback called "*Palio*", a station wagon called "*Palio Weekend*", a four-door sedan called "*Siena*", a pick-up called "*Strada*" and a mini-van. Four levels of interior and various engine sizes increase the range of options.

[8] Cooperation between Fiat and the Polish industry has been ongoing since 1921. In 1993 Fiat acquired 90% of FSM, and established Fiat Auto Poland.

[9] Fiat won an international tender to manufacture (CKDs) and distribute a popular car, launched by the Rabat Government in 1994.

[10] In Turkey Fiat operations dates back to 1971, to the agreements between the Italian group and the Turkish Group Koç, which developed into the establishment of the Tofas company, operating in Bursa.

[11] Fiat had major problems in India. Indauto, the joint-venture with Doshi, an Indian group owner of Premier Automotive Ltd. with which the Italian group has had relationship for a long time, failed.

[12] This model, named *Fabbrica Integrata*, is an Italian, adapted version of lean manufacturing developed in the early '90s and fully implemented in the highly successful greenfield plant in Melfi, South Italy. Following "lean" principles, the main features (Camuffo and Volpato, 1995) of *Fabbrica Integrata* are: advanced and flexible production technology, the adoption of lean manufacturing concepts (just in time, synchronous kanban, kaizen, job rotation, management by sight, quality tracking, etc.), key partner suppliers located close to the assembly plant, a "flat" organizational structure, organizational units based on process logic and linked to client-supplier logic, decentralization of responsibilities and functions, focus on skills and human resources as performance drivers.

[13] In technical terms, choices regarding plant and machinery layout are often forced ones. In brownfield sites choices often depend on previous arrangements. In Brazil, for example, lack of space prevents greater use of automation and new technology or else leads to new lines being adapted to the layout of the previous ones. In Argentina, on the other hand, the creation of a new assembly plant allowed optimal organization of technology, manual works and plant layout.

[14] Naturally, the presence of national/local suppliers also remains strong because of local content restrictions on the product or other logistic factors.

[15] Also some Italian plants have recently adopted modular manufacturing practices.

[16] Market problems and technical difficulties led Fiat to downsize the experiment and freeze the related investment.

[17] In reality, however, this process is theoretical and can be applied only in greenfield plants. Labor laws and industrial relations are so different from country to country, that that work organization and human resource management practices have to be adapted in order to take into account the factory's consolidated situation or external reality. This last point refers both to the available suppliers and to the socio-cultural make-up of the local area. Suppliers have their own working times and methods, which may not always be compatible with the car manufacturer's (especially when it comes to just-in-time). Since manufacturers cannot use the same suppliers they use at home, they will need to involve local suppliers, who sometimes already work for other carmakers (or that do not match expectations) and, to a certain extent, adapt to them. As regards the external environment - i.e. the local society - the main difficulty occurs when industrial culture is not widespread and the local traditions and religion are very different. The result can be a different attitude towards time compared to developed western society. In India, for example, there have been problems introducing certain work rates and methods.