

# MODULARIZATION, KNOWLEDGE MANAGEMENT AND SUPPLY CHAIN RELATIONS : THE TRAJECTORY OF A EUROPEAN COMMERCIAL VEHICLE ASSELER

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Automotive firms are facing increasing pressures in order to remain competitive. The evolution and transformation of technologies, market structure and customer needs push firms to reduce the time to market of products, increase technological and organizational flexibility and gain access to available - within and outside the firm, local and global - competences and capabilities. Firms are attempting to achieve higher product variety, lower costs and lead times by introducing modularization within their product configuration.

This paper aims to provide preliminary empirical results on the effects of components modularization on supply chain relations and point out the new “knowledge requirements” which both assemblers and suppliers are attempting to achieve. Specifically, it aims to investigate the dynamic linkages among new product configuration based on modularity, assemblers’ and suppliers’ organisational architectures and their internal balance of technical and organizational competences. In order to explore such dynamics

this paper examines the experience of IVECO<sup>1</sup>, a European commercial vehicles assembler, and one of its main suppliers - Alpha - within the implementation of a major product development project in the light vehicles segment. The area of product development can provide an effective “window” on changes of final assemblers’ and suppliers’ strategies concerning their respective role in the vertical relationships and the exploitation, acquisition or development of the required competences within the new vertical configurations.

The remainder of the paper is divided into three paragraphs. The second paragraph aims to review contributions on the recent structural changes affecting the automotive industry and outlines a preliminary analytical framework. The third

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<sup>1</sup> We wish to thank IVECO and Alpha for their availability and support in developing this case-study. Alpha is the code name for the supplier firm investigated in this analysis. This paper shows preliminary results of an ongoing research project on international supply chain management in the automotive industry. It is based on interviews with company managers and on company reports and documents. Usual disclaimers apply.

paragraph develops the analysis of the case-study by providing first the main trends of IVECO's strategies concerning market competition, product configuration, organizational architecture and knowledge management, and then by analyzing changes in the bilateral relationship between the commercial vehicle assembler and Alpha. The fourth paragraph provides a brief analysis of the findings of the paper and outlines steps for further research.

### **THE NEW CHALLENGE FOR AUTOMOTIVE FIRMS: THE TRANSITION TOWARDS A "REGIME OF VARIETY"**

There is a wide agreement that automotive firms have experienced a difficult transition from a Fordist approach to production and business organization - based on highly vertically integrated firms implementing mass production and maintaining a limited role for suppliers - to more flexible and "lean" organizational models, under the influence of manufacturing techniques implemented by Japanese companies (Boyer et al., 1998; Helper, 1991). Such a transition causes the emergence of the "regime of variety" which is embodied in new design, production and delivery patterns (Coriat, 1995). The introduction of new processes show a distinctively "cumulative" and "path dependent nature" (Camuffo and Volpato, 1996: 813).

The first emerging trend within the new "regime of variety" is the absolute emphasis by final assemblers on market orientation and customer satisfaction. Vehicle makers have attempted to manage the increasing customer's behavior variety by attempting to achieve higher correspondence between customer's needs and vehicle specifications and by offering higher product variety (Coriat, 1995; Calabrese, 1997).

The second trend is the growing relevance of modular product architecture as opposed to integral architecture<sup>2</sup>. Final assemblers introduce modular

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<sup>2</sup>If a product has a "modular architecture" components have "de-coupled interfaces" between them. This means that "a change made to one component" does not imply "a change to the other component in order for the overall product to work correctly". In case of an "integral architecture" of a product there are

vehicle configurations in order to achieve both increased product variety and reduction costs by promoting commonalization and carry-over of components among different models (Calabrese, 1997; Muffatto, 1999). Modular configuration - combined with the increased technological complexity of vehicles and parts - implies stronger cooperation in design and engineering activities with suppliers, which are therefore highly involved in product development processes. Such changes imply that suppliers increasingly gain responsibility for design activities (Liker *et al.*, 1996) of whole modules/system rather than supplying single parts or components (Calabrese, 1997). The new role as system integrators pushes suppliers to undertake alliances and mergers on a global scale (Automotive Industries, March 1998). Within the new approach to product configuration both assemblers and suppliers aim to develop "product families" (Meyer and Utterback, 1993), which comprise basic technical platforms and allow for matching product variety, spreading of development costs over high volumes and achieving economies of scale in production. The "product family" framework encourages the development of a "multi-process approach" to product development activities, which allows for increasing sharing of components and technical and organizational knowledge across product development projects over time (Zagnoli and Cardini, 1994; Cardini, 1997).

The third main trend is the new organization of internal and external processes, leading to the development of "internal" and "external networks" (Boari et al., 1992). Final assemblers are attempting to upgrade or modify their internal processes to improve efficiency levels, decrease lead times and promote higher cooperation and communication flows between internal units/functions, thus developing highly flexible and dynamic "internal networks" (Coriat, 1995; Calabrese, 1997). Three areas have been targeted to introduce new organizational practices: production processes, delivery systems and product data management systems. Final assemblers are attempting to reduce production process complexity, increase automation along the

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"coupled interfaces between components" (Ulrich, 1995: 422-423).

assembly line and achieve higher integration between production and delivery systems implemented by suppliers which are based on Just-in-time mechanisms (Benassi, 1994; Camuffo and Volpato, 1998). Another major area of intervention is the introduction of product data management systems, whose role is to set up common codes for documentation of vehicles and parts (Calabrese, 1997).

On the external side, final assemblers are redesigning the whole supply chain configuration. Strong reduction of suppliers and higher interaction and communication flows with suppliers are deemed necessary to increase market performance, reduce time to market and improve the technological content of products. Such approach aims to overcome the rigidities of the “arm’s length approach”, where most of the production is developed in-house and relations with suppliers are based on short-term trading and minimal cooperation between buyer and suppliers. According to the new “partnership-based” approach, the final assembler would develop extensive outsourcing and would promote strong technological and logistical interdependence and long-term relations with its suppliers. The number of direct suppliers is reduced and the supply chain is structured into different levels (first, second, third-tier suppliers), with first-tier companies supplying customized and more complex parts and components, while being in charge of coordinating second-tier suppliers (Lamming, 1993)<sup>3</sup>. Dyer (*et al.*, 1998) show that Japanese automotive firms are implementing a supply chain strategy which includes both arm’s length and partnership-based patterns, the so-called “strategic supplier segmentation”: while relations with suppliers producing customized components are characterized by higher cooperation and transaction dependence, relations with firms supplying standardized products are based on less interaction and lower transaction dependence. Such approach seems to be highly followed with respect to the

development of international sourcing strategies. The imposition of strict quality standards on the supply network and high involvement of suppliers in product development activities promotes the emergence of global sourcing network where multinational components firms supply assemblers located in different markets, while local suppliers are often engaged in producing low-tech and low value-added components (Humphrey and Salerno, 1998). Such changes in governance mechanisms have required the introduction of new practices such as the imposition of new supplier selection procedures and new quality and delivery control mechanisms (Coriat, 1995). There is growing evidence that supply chain restructuring processes concern first-tier suppliers or “system integrators” as well (Buongiorno and Conca, 1999; Automotive Industries, October 1999).

The transformation of internal and external processes by final assemblers is shaped by the development of “relational” resources in terms of using and exploiting information technology communication channels and of promoting inter-functional cooperation based on team-work and informal mechanisms for information exchange (Clark and Fujimoto, 1991; Calabrese, 1997). One of main challenges for both assemblers and suppliers is to successfully manage the increasing interdependence, with a main concern over how to develop and maintain relationships based on trust and how to integrate a variety of business cultures and practices which are highly embedded within firms<sup>4</sup>.

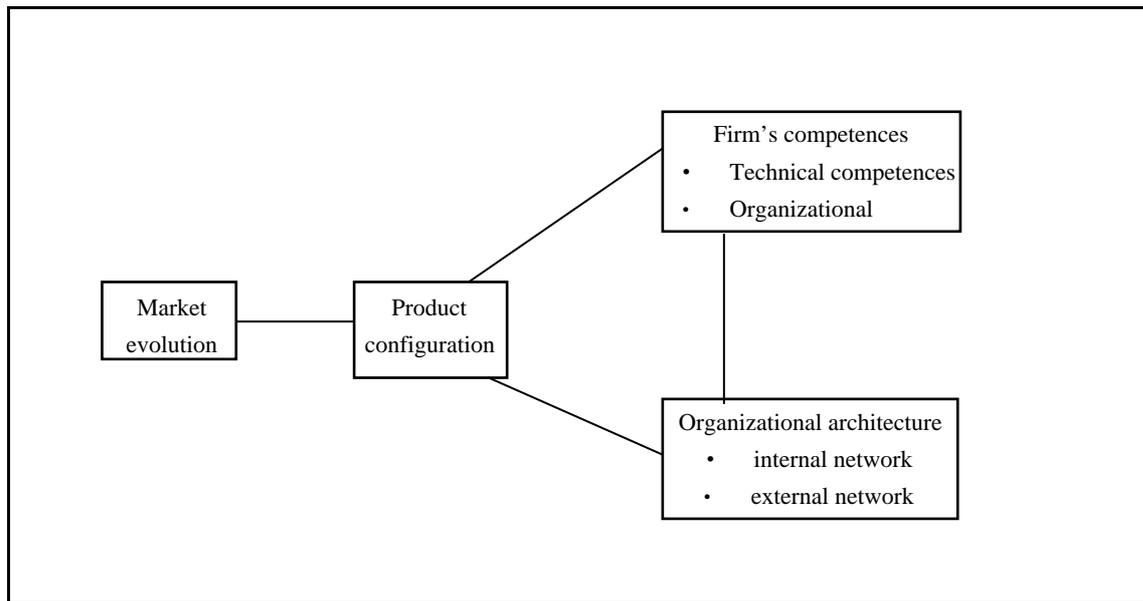
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<sup>3</sup> According to Lamming’s definition, “first-tier suppliers are those that integrate systems for direct supply to the assembler, or have a significant technical influence on the assembler while supplying indirectly; second-tier suppliers are those that supply components to first-tier firms for integration into systems, or provide some support service” (1993: 188).

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<sup>4</sup> The importance of the length of time in examining the interaction between firms and their local context is underlined by Castellani and Zanfei (1998), who argue that the development of cooperative linkages by multinational firms is closely linked to “the historical presence in the market, i.e. the extent that they got rooted in the local context over time” (1998: 8).

Figure 1. Preliminary analytical framework:  
the emergence of the “regime of variety” and new knowledge requirements



Therefore, the basic variables -highlighted in the literature- shaping the emergence of this new “regime of variety” in the automotive industry are market evolution, product configuration and organizational architecture (Figure 1). It seems apparent that the transition to a “regime of variety” requires new knowledge development strategies by both final assemblers and suppliers. While there is growing empirical evidence that final assemblers have been implementing new knowledge management strategies to improve variety management (Calabrese, 1997; Coriat, 1995), it could be argued that a more deep analysis of suppliers’ behavior in such evolution is highly needed. Therefore, this paper aims to provide preliminary empirical insights on the dynamic linkages between “variety management” and knowledge management strategies by examining both final assembler and supplier’s experiences in such evolution. Therefore, this paper attempts to point out both final assemblers and first-tier suppliers’ changing objectives and practices in terms of development and upgrading of technical and organizational competences<sup>1</sup> to effectively

<sup>1</sup> In this paper technical competence is defined as the “ability to develop and design products and processes, and to operate facilities effectively” (Dosi and Teece, 1993: 6-7); the concept of product includes physical and intangible goods and services. Organisational competence is defined as “allocative competence -

manage the new product, production and supply chain configurations within the “regime of variety”. In order to achieve such goal this paper develops first the analysis of basic trends of IVECO’s light vehicles product and supply chain renewal and then the main patterns of the evolution of IVECO-Alpha bilateral relationship.

## EVOLUTION OF IVECO’S COMPETITIVE STRATEGIES IN THE LIGHT TRUCK SEGMENT

IVECO has been established in 1975 through the merger of a group of European companies operating in the commercial vehicles’ sector<sup>2</sup>. The main task during the 80s has been to manage the restructuring process and the development of a

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deciding what to produce and how to price it; transactional competence - deciding whether to make or buy, and whether to do so alone or in partnership; and administrative competence - how to design organisational structures and policies to enable efficient performance” (*ibidem*: 6). Organisational routines are therefore defined as “patterns of interaction that represent successful solutions to particular problems”, which embody organisational knowledge developed through learning activities (*ibidem*: 11).

<sup>2</sup> IVECO has been established in 1975 after the merger of Fiat Veicoli Industriali, OM, Lancia Veicoli Speciali (Italy), Unic (France), Magirus (Germany).

common identity through all IVECO businesses and operations across Europe. Such processes have been implemented and accelerated by IVECO by focusing on two specific areas: the development of a new Medium/Heavy Vehicle range (Euro) and the establishment of other IVECO companies in

United Kingdom (IVECO-Ford Truck Ltd in 1986) and Spain (acquisition of Enasa in 1990). A large amount of resources has been allocated to manage such changes in product range and the establishment of an efficient organization and a common business culture.

Table 1. *Truck Market in W. Europe - Daily Light (3.5 GWT only) –IVECO Share %*

	1996	1997	1998
France	26.0	24.2	13.7
Germany	12.8	14.7	12.0
Italy	46.9	44.9	42.2
Spain	19.4	17.0	15.5
UK	8.0	8.1	7.8
Others	16.1	14.6	13.5
TOTAL	22.4	20.4	18.8

Source: IVECO

In Europe, the commercial vehicles sector has experienced an ongoing restructuring process which has led to the acquisition or exit of many firms<sup>1</sup>. IVECO has managed to face the increasing competition mainly by protecting its leadership in Italy and attempting to penetrate European markets, thus being able to overcome the strong reduction in demand during the years 1992-1993. However, even though in recent years IVECO has increased its production volume and sales in the 3.5tns segment, its market share has decreased in Europe and Italy as well (Table 1). IVECO has had to manage its competitors' penetration in Italy and the differences in national markets. While North European markets are characterized by a growing number of customers with large fleets operating in the logistics sector, the Italian market is still dominated by small firms and therefore is still highly fragmented on the demand side. Therefore, IVECO has to develop new competences and organizational structures to compete in the other European markets.

In order to strengthen its position in the Italian market and further penetrate in foreign markets, IVECO has launched the renewal of the light vehicle range by starting the S-2000 project. This initiative, which will be examined in detail below, has meant also the development of new organizational routines within the Light Vehicles units. With respect to the business strategy in the light segment, the S-2000 project was deemed to achieve two main goals:

- to increase competitiveness in the van segment and maintain the leadership in the truck segment;
- to gain market shares in the 3tns segment, facing the competition of vehicles which are car-derivative, such as Fiat Ducato, where IVECO has always had a marginal position, and in the 6.5tns segment with more powerful engines, while IVECO before did not exceed 6.0 tns.

IVECO's top management aimed also to increase product variety, reduce product and production complexity and introduce new managerial and organizational practices to achieve better product development performances.

<sup>1</sup> According to IVECO figures, in 1940 40 truck producers operated in Europe; in 1999 only 11 truck producers were competing in the European market.

The S-2000 project has been carried out while IVECO had been developing two strategic paths. First, IVECO has started to reshape its value chain by rationalizing production processes and by integrating forward activities which allow the company to implement an integrated marketing strategy which includes a wider range of services, mainly financial. These activities, which are deemed to provide higher returns in the long term, are managed by Transolver, a new company within the IVECO Group engaged in financial services and also hiring after the acquisition in 1999 of Fraikin Group, a French company leader in the van/truck hiring. This acquisition has been mainly

motivated by IVECO's willingness to gain the technical and organizational competences to run successfully these new businesses.

Second, IVECO has pushed further the globalization process in terms of production and distribution (see Table 2). IVECO's effort and resources have been directed towards four strategic areas, where markets are perceived as potential sources of additional sales and as production platforms as well: South-America, Turkey, India and China. Russia could represent in the future an additional strategic area, however the political and economic situation is still too uncertain for a strong commitment by IVECO.

Table 3. - *Relevant events - IVECO light vehicles range*

1975	Establishment of IVECO
1978	Launch of the Daily
1986	Production license to Yuejin Motor (China) for Daily production
1986-89	Restyling – introduction of new engines
1994	Starting of the internal organizational restructuring process
1995	Establishment of IVECO-Kraz (joint-venture with Kraz and the European Bank for Reconstruction and Development for light vehicles production) and IVECO-Motor Sich (joint-venture with Motor Sich for production of gearboxes) in Ukraine; Establishment of Naveco (joint-venture with Yuejin Motor for production of light vehicles) in China; Launch of the S-2000 project.
1996	Establishment of Haveco (joint-venture with Yuejin Motor and Hangzhou Corporation for production of gearboxes) in China; Launch of Model Year 96.
1998	Launch of Model Year 98; Establishment of Fiat Brasil Ltda.
1999	Launch of Platform F1A for new light range engines; Acquisition of Fraikin Group.
2000	Launch of the Daily City Camion (S-2000 Project); Daily is named "Van of the Year"
2001	Expected launch of the new light range engine

## **THE S-2000 PROJECT: IVECO'S RECONFIGURATION OF PRODUCT ORGANIZATIONAL ARCHITECTURE IN THE LIGHT SEGMENT**

### **The implementation of a new product architecture: the introduction of modularization**

Since 1989, the Daily had been configured by using a number of standard combinations of parts and components. Customer choice has been implemented by adding or excluding optional items from the basic variant, and the same configuration process had to be implemented within the Engineering and Manufacturing units which were operating with different product documentation systems. Each time there was a choice different from one of the 300 standard combinations, the Engineering and Manufacturing units had to provide a whole new vehicle documentation. This approach caused the configuration process to be very repetitive and needed time and resources to be implemented. A related issue was the difficult interaction between Marketing and Engineering, whose different languages and codes affected the degree of correspondence between customer's requests and IVECO' ability to satisfy them.

To address such issues, IVECO has launched the development of the Product Representation Process (PRP)<sup>1</sup>, a new approach to product and production documentation, to be tested for the first time within the S-2000 project. The PRP has been developed to achieve a number of objectives:

- to provide a Common Language to all functions and operational units involved, such as Marketing, Engineering, Production and Logistics, thus reducing costs related to information flows;
- to reduce the time to document product and process engineering activities of a new vehicle (time to market);
- to be able to react in a more adequate and flexible way to customers requests by increasing configuration flexibility and reducing the time to order.

Therefore, the launch of PRP represents an attempt to introduce a new "organizational routine" aimed at facilitating technical knowledge sharing and increasing internal processes efficiency. At the same time, IVECO has been willing to push for a high degree of modularization of the vehicle, in order to achieve higher product variety while at the same time increasing the ability to achieve standardization and commonization of components within products belonging to the same "family". Without the introduction of the PRP, IVECO's Engineering would have had to deal with more than 4000 basic combinations, requiring a huge amount of resources. The introduction of PRP has therefore radically changed the way parts and components are combined together, given that optional items are regarded as standard components and the product configuration is a direct result of the choice of the customer. Such a tool has allowed IVECO to control customers' choice within specific "boundaries" in terms of product configuration.

The configuration process is based on a set of 123 functions/modules. Functions/modules are divided in Primary Functions, in the light of their price and weight (such as engines and gearboxes), and Secondary Functions. Many parts/components are due to be supplied to IVECO as whole functions and not as single components. This trend has included parts such as gearboxes and axles. The supply of complete systems/modules has increased the degree of homogeneity of the parts' characteristics, such as in the case of internal trimming with respect to colors.

Through the combination of 123 functions/modules it is possible to obtain 3,000 variants -while previously IVECO was able to offer 500 variants - according to a set of only 3,300 rules, while the configuration of the Model Year 98 (MY98) required more than 90,700 rules. The ICP ("IVECO Configuration Platform") program is the main tool managing the whole configuration process through the combination of functions/modules according to the customer's choice. The ICP program is able to indicate ex-ante which functions/modules are affected by the specific choice of the customer.

According to interviewees, the emphasis on product customization seems to have lead IVECO to offer higher variety to its customers when

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<sup>1</sup> The PRP approach is based on solutions developed by Digital for IVECO; the current version has received inputs also from Andersen Consulting.

compared to car assemblers<sup>2</sup>. The introduction of PRP has further accelerated such process of variety generation. A large number of optional items are treated independently by Marketing, which is willing to offer a wide range of choices and is reluctant to provide a more limited number of standard combinations<sup>3</sup>.

The application of PRP while designing the new light range has been characterized by two relevant patterns. First, the objective a completely modular documentation has not been reached yet. This is not because suppliers have not been able to match the requested effort by IVECO, but because IVECO'S Engineering has not been able to change fully its documentation routines. In the light of the lack of time, resources and specific capabilities, IVECO's Engineering has not been able to implement a modular documentation system since the beginning.

Second, the concept of variety has not included the concept of national variety. IVECO has chosen not to spread product development costs over a high number of markets. The Daily City Camion has a distinct regional European dimension both in terms of market target and in terms of "inputs" (parts and components to be installed in the new vehicles, involvement of suppliers or design firms in the Platform). Specific adaptations or variants to be considered for the South American or Chinese markets have not been on the S-2000 project agenda. The option of introducing specific adaptations to later develop a bus version for the Chinese market has not been implemented. Such a pattern is the result of the combination of two sets of factors:

lack of a specific knowledge within the S-200 Platform about potential technical opportunities /

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<sup>2</sup> IVECO interviewees have reported that dealing with IVECO's high product variety has been a learning experience for Andersen Consulting and Digital as well.

<sup>3</sup> The highly customized nature of the Daily is shown by the procedures concerning customers' choice of the vehicle case. Such selection is managed mainly by dealers and not by plants. Only 30% of Daily vehicles are chosen and assembled with standard cases. Therefore customers choose their own specific case and dealers are in charge of installing cases on the vehicles. Keeping cases in stock at the plant is considered too costly and would not offer the same degree of variety as dealers do.

obstacles in including the emerging markets within product specification activities;

lack of time and resources within the S-2000 platform to deal with national varieties in terms of market needs and regulations.

### **The implementation of new organizational architectures**

The renewal of the light range and the introduction of the Daily City Camion represented a relevant opportunity to develop new organizational practices and/or to modify organizational routines within the Business Light operational units. Such changes could be categorized in the development of "internal" and "external" networks. The new product architecture and philosophy has caused IVECO to redesign how internal functions/units interact with each other and how IVECO interacts with other firms.

#### *The development of "internal networks"*

The establishment of the S-2000 platform

In order to develop the new light range IVECO's top management has adopted an organizational platform to carry out product development activities, which started operating at the end of 1995 after that market research and preliminary engineering activities had been completed. The S-2000 platform has represented a new approach in product development management. The main previous project, notably the Euro Cargo/Euro Star/Euro Trek, had been conducted over more than 8 years and was based on a sequential approach to product development with the involvement of different functional departments. The S-2000 platform, instead, required staff to be involved in a permanent or part-time basis, with the Project Manager playing a leading role. The main bodies within the platform were the Steering Committee, composed by IVECO senior executives with the objective to monitor the project implementation, the Project Manager, the Core Team with representatives from all functions and ad hoc teams dealing with specific functions/components/tasks.

IVECO has conceived the platform to represent a new approach for internal cooperation and communication and therefore as a basis for setting up new internal routines. More than 100 people have been permanently involved in the initiative,

and all activities have highly involved suppliers and design firms. IVECO's top management has also attempted to foster new management practices by supporting specific training for senior staff and by involving managers and designers coming from other firms with experience in inter-functional cooperation and team-based activities. However, the development of a "platform approach" has been also shaped by the partial survival of "a functional approach" to cooperation and communication. Personnel within the platform have encountered difficulties while shifting from previous managerial patterns to the new procedures and routines introduced by IVECO's top management.

The emergence of a new "process architecture"

The production process for the MY98 was highly fragmented. All activities were carried out along the assembly line. This allowed for higher control on the workforce activities and for full supervision on the quality of the final product. The testing and quality control required long time and resources because of the high number of line activities and the high number of interventions carried out by workers and machinery on the vehicle.

The introduction of the new light range has caused the renewal of the production process. The overall objective has been to reduce the production complexity and the throughput time of the vehicle. The new process embodies the principles of the "Fabbrica Integrata" as implemented by other Italian companies as FIAT Auto (Camuffo and Volpato, 1998) and Piaggio. The main process innovations are: i) the set up of "production/assembly units" far from the main assembly lines; ii) the introduction of a high level of automation. The plant layout seems to follow the new product architecture. Assembly Units are devoted to the assembly, testing and quality control of single parts/components and operate far from the vehicle assembly line. These organizational changes have minimized time and resources once devoted to the testing and quality checking of the final product. Once function/modules are tested and checked they are transferred to the assembly line on a JIT basis, with very short lead times. The assembly line has therefore become more lean and flexible. Workers are engaged in operating robots,

controlling the sequencing of vehicles or in very simple operations such as transferring and welding components. Thanks to the short lead time in the transfer of functions from assembly units, there has been a gain in space and order along the assembly line. The whole assembly and material flow process is governed by the IVECO Manufacturing Information System (IMIS), which has been introduced in 1989. IMIS system is now connected with the new ICP program, which manages the vehicle configuration within the PRP framework and therefore interacts with Marketing and Commercial units. Suppliers are able to interact with IMIS but are not involved in the PRP/ICP system. The introduction of PRP has therefore meant a change in the "head" of the IT infrastructure.

These relevant changes have required IVECO to upgrade its stock of organizational and technical knowledge. Technologists and process engineers have been highly involved in the S-2000 platform, therefore being able to communicate their priorities in terms of process equipment and layout and to find common solutions with IVECO's product engineering, component and tools suppliers' engineering. Production planning personnel has been trained in order to acquire knowledge on the implications of the introduction of PRP/ICP framework. In addition to the introduction of a new layout and highly automated machinery, IVECO has hired a very young and highly educated workforce to run the new equipment. Young workers have been trained to run the new robots, while senior workers and technicians are due to support them in problem-solving activities in the light of their experience in the shop-floor.

The development of the new process architecture is still in the making. Four main patterns have emerged and shaped the full implementation of the new production process. First, some of the IVECO plants are not involved yet in the IT infrastructure developed to accelerate and manage material flows. Plants in Spain and China are still not involved in the IMIS system, while other IVECO plants producing parts/components are not involved in the PRP/ICP system. Therefore engines cannot be transferred as complete "kits" within the Suzzara plant. Second, not all functions/modules provided by external suppliers are managed by the plant as single kits

because of the delays in changing documentation routines - above outlined - which therefore has limited the capacity of the ICP program to provide a completely modular configuration of the vehicles. Third, there is still lack of communication between IMIS and the assembly units automation systems and programs within the plant. This implies that assembly and production orders are sent to the assembly units whose personnel has to “translate” them in order to launch the program of the local unit system.

The new division of labor within the internal network on a global scale

Differences in the product strategy to be implemented in Europe and emerging markets seem to have further specified the mission to be carried out by assembly plants in Ukraine, Brazil and China. While IVECO’s European plants are engaged in assembling the new light range and producing the newly designed components, plants in China, Brazil and Ukraine will be responsible for the assembly and production of light vehicles and components for all emerging markets. The emerging division of labor among IVECO’s operations in Europe and abroad highlights a number of challenges that IVECO has to deal with. First, the apparent different product configuration and variety between Europe, China and Brazil could affect the degree of carry-over along a regional dimension. Second, the customer service management for the MY98 (Model Year 98) could be affected by the quality level of components and parts produced in Brazil and China; this could mean that suppliers based in Europe could have to

maintain the production of parts and components for the MY98.

*The development of “external networks”*  
Increasing outsourcing in the production processes

The S-2000 project has provided the opportunity to develop a new configuration of production processes with a higher use of external competences and capabilities. The overall objective has been to outsource those production phases and processes where internal competences were not sufficient and/or where cost reduction could be achieved. The vertical disintegration has been implemented in two areas. The first area is represented by production processes. The sheet metal pressing activities have been outsourced to companies leaders in this field, with the guarantee of high quality and cost reduction. The second area is the production of parts and components, with the partial outsourcing of gearbox production, which has been co-designed and produced jointly with ZF, a German company leader in this field.

The renewal of the supply base

Since 1978, the supply base for the light vehicle range has experienced “incremental changes” with respect to their relations with IVECO. Suppliers have been producing parts and components as requested by IVECO and their involvement in product development has been very limited. Starting in 1989, IVECO has gradually introduced just in time mechanisms and at the beginning of the 90s there has been an effort by IVECO in setting up strict quality standards.

Table 3. - *Suppliers selection criteria – S-2000*

Structural quality	Certified suppliers with high scores and low level of non-conformity
Logistic performances	Flexible suppliers able to provide a high service level
Know-how and development capabilities	Suppliers with strong R&D units able to undertake design processes
Costs	Competitive suppliers in terms of price and efficiency
Financial stability	Suppliers able to guarantee growth, investment and long-standing relations

Source : IVECO

Table 4. - *New supply chain configurations, routines and selection of components*

New "BUY" - Outsourcing	Co-design	Co-location	Components supplied as complete modules
Gearbox	Conditioning	Complete dashboards	Heating
Sheet metal pressing	Front suspensions	Seats	Conditioning
	Gearbox	Front suspensions	Complete dashboard
	Braking system	Bumpers	Internal trimming
	Dashboards	Cables	Braking system
	ABS		Front, side, rear lighting
	Seats		Noise shields

Source: IVECO

The S-2000 project has marked a significant shift in IVECO's relations with suppliers<sup>1</sup>. The renewal of the light vehicle range has provided IVECO with the opportunity to codify formal supplier selection criteria and procedures which have emerged during the years before. The initial target at the beginning of the S-2000 project was to develop a supply base composed by 250 "best-in class" suppliers. The total number of suppliers has shifted from 540 in 1996 to 260 in 2000, with 80 new suppliers. The total number of suppliers would have decreased even without the need to launch the renewal of the light range. IVECO set up very strict criteria for the selection of new suppliers (Table 3): while price has maintained its relevance, a major emphasis has been placed on development competence, quality and risk sharing. Suppliers are now considered as equal partners, sharing risks and responsibilities with their final customer, being involved in the supply of components and in customer service as well. Their commitment has to be maintained over time by further attempting to decrease costs. The new criteria imposed on suppliers have caused a "natural selection" leading to a reconfiguration of the supply chain with a growing number of suppliers of complete

functions/systems (see Table 4). A high number of MY98 suppliers have not been confirmed because they did not provide guarantees and commitment in terms of quality, delivery and product development. In addition to the new supplier selection criteria, IVECO has launched the "Guided Growth" scheme to improve suppliers' quality and costs. For each function/system a Working Group has been set up to monitor quality level and to foster costs reduction.

While suppliers have been requested to increase their performance on a number of dimensions, a parallel task is to be achieved by IVECO's operational and functional units. Notably, Purchasing managers are due to strengthen their "relational capabilities" by promoting a long-term approach with suppliers, facilitating the integration of suppliers within the new logistic process and playing the role of coordinators with respect to all activities, including co-design, carried out by IVECO with its suppliers. This new policy is therefore promoting a shift - in Purchasing managers approach - from being price-oriented to comprising a number of new aspects, such as quality, level of delivery service, product development activities, while dealing with suppliers. In order to speed such process young Purchasing managers have been introduced at the plant level.

<sup>1</sup> Co-design cooperation between IVECO and Renault has brought twenty new suppliers in IVECO's supply base.

New external routines with suppliers: cooperation in co-design

Previously the involvement of suppliers in product development has been very limited. IVECO's design and engineering units were able to manage product/component design and innovation without using external resources. The increasing vehicle complexity and variety and the degree of technical knowledge required for some component design activities have pushed IVECO to acquire external competences by developing co-design cooperation with suppliers, design firms and with other Fiat Group Units<sup>2</sup>. Another major factor pushing IVECO to start co-design cooperation with external actors has been the need to reduce time to market and time devoted to the product documentation process.

Suppliers and design firms have been highly involved in the S-2000 platform: 95 suppliers and various design firms have been involved in co-design activities. The extent of their involvement has been further expanded in the light of the low level of carry-over implemented by IVECO with respect to the Daily City Camion<sup>3</sup>. Except for the 3tns model, among the most critical parts only the braking system and the engine have not been modified<sup>4</sup>.

Two main difficulties have been reported with respect to co-design cooperation with suppliers. First, suppliers have not always been ready to follow the timing and schedule planned by IVECO. Suppliers did not believe at the beginning that the new light range would have been launched in three-four years; there was often lack of continuity in the interaction with the assembler after the development of prototypes and suppliers were not ready when the final testing had been implemented by IVECO.

The second critical area concerned component modifications management which has required

close coordination between IVECO and its suppliers. In some cases modifications have been implemented by IVECO after those proposed by suppliers have failed testing. Moreover, very often modifications required by process engineers have been introduced by suppliers without changing the documentation concerning the specific components, therefore causing inefficiencies in the delivery and logistics activities and slowing the assembly process.

The co-design experience with suppliers has been very relevant in two cases. IVECO has agreed to jointly develop and produce the cabin with Renault and the gearbox with ZF. In both collaborations IVECO and its partners have set up cooperative joint-ventures. Under IVECO's perspective, these initiatives were due to accomplish four main goals:

- reduction of product development costs to be shared with the JV partner;
- reduction of component development time;
- exchange and acquisition of technical know-how by cooperating with companies leaders in their respective fields;
- achievement of economies of scale at a level difficult to be obtained by competitors (cabin production doubled with 200.000 cabins per year), which leads to savings in costs to be invested in further product development;

Cooperating with Renault has been a very stimulating and fruitful experience. While Renault has kept property rights over thirty cabin components, IVECO is in charge of the whole production. IVECO has learned new design and testing techniques and new patterns for documenting parts and components. In this case PRP has not been introduced and IVECO and Renault had agreed on common rules and routines to conduct design activities. Another relevant aspect of cooperating with Renault has been the starting of supply relations with Renault's suppliers.

Cooperating with ZF has been based on a different division of labor among partners when compared with Renault. Involving ZF in developing the new gearboxes has been a compulsory choice for IVECO in the light of the restricted timing and the lack of resources and know-how to develop two kinds of gearboxes (the

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<sup>2</sup> It is remarkable that IVECO has started to promote technological cooperation in engine development as well by setting up in 1996 a joint-venture (EEA - European Engine Alliance) with New Holland and Cummins Engine Co.

<sup>3</sup> For example, one van variant has been configured with 220 new part numbers and 5 "carried over" part numbers.

<sup>4</sup> In 1999, IVECO set up the F1A platform to develop the new engine for light vehicles, which is scheduled to be launched in 2001.

5g and 6g). ZF has been preferred to local companies in the light of its better reputation. ZF has developed the 5g gearbox according to detailed specifications provided by IVECO, while the 6g gearbox has been supplied by ZF to IVECO as a “black box” component. ZF has been willing to keep property rights over the 6g gearbox given that it forecasts a high increase in market demand (with customers such as Renault and Mercedes) for this kind of gearbox in the light of the increasing power of engines for light vehicles and of the increase in demand for automatic gearbox, which can be easily developed from the 6g gearbox. Therefore, IVECO is supposed to be ZF dependent for the 6g gearbox for the next four years. One of the main fears for IVECO with respect to gearbox development is the possibility to lose further know-how and technical competences in this field, which would impair IVECO’s capacity to exploit the fact that in four years the property rights for the 6g gearbox will be transferred from ZF to IVECO.

Within the S-2000 project IVECO has increased its involvement of design firms, which have been in charge of highly complex design projects. IVECO’s dependence on design firms contribution has increased and is deemed to be higher in the future.

Even though also before IVECO was dependent on suppliers’ know-how for specific components, such as panel instruments, the introduction of co-design with suppliers and design firms represents a significant shift in IVECO’s knowledge management strategies: while before IVECO maintained property rights over all drawings, therefore managing modifications as well, now many suppliers in co-design maintain property rights over their product development effort and are in charge for modifications management. This means that suppliers and design firms can utilize the outcomes of their product development activities in other projects and with other automotive firms. Therefore IVECO has to rely on its partners -suppliers and design firms- for developing an adequate management of technological and business secrecy.

IVECO has had to set up appropriate “interfaces” in order to play an active role in co-design activities. IVECO’s product engineers have had to face two difficult tasks. Firstly, they have had to manage and coordinate system-level product

development activities involving also external actors such as suppliers and design firms, rather than focusing on single components as before. Secondly, they have had to understand and take into consideration within the product engineering process instances and requests from other functions/units such as Purchasing, Finance and Process Engineering. In order to deal with such challenges, IVECO has involved within the S-2000 platform consultants and engineers with previous experience within the Fiat Group or in other automotive companies. Similar tasks had to be performed by process engineers and technologists, which have had to change their routines in terms of production process documentation and interaction with product engineering. In order to facilitate the interaction between process and product engineering, process engineers and technologists have been trained for six months in Torino and have received the support and advice of external consultants.

#### New delivery patterns

The introduction of PRP and modular configuration has modified existing suppliers’ delivery routines under two dimensions. First, suppliers are required to satisfy IVECO’s orders with respect to increased variety of components to be delivered at the plant. Therefore suppliers might have to produce or assemble a high number of completely different functions/modules for the same delivery. Second, in addition to increased variety in production and delivery there has been a reduction in lead time and a higher delivery performance required. Suppliers have to achieve 98% in service level, which is the same target set up by IVECO for delivery of vehicles to customers.

The introduction of PRP has allowed for an increased visibility and transparency of the whole process from customer’s order to suppliers’ delivery. Moreover, the new plant layout requires suppliers to strengthen their JIT performance given the reduction of stocks within the plant and along the assembly line.

Therefore, the new product and process architecture has made more difficult and complex for suppliers to fulfill production programs. Managing such a higher degree of external dependence is a hard task for IVECO plant’s managers, which are pushed by the top

management to renew their perception of suppliers and view them as partners and as an “integrated extension of IVECO’s plants”.

### **NEW PRODUCT, ORGANIZATIONAL ARCHITECTURE AND CHANGES IN SUPPLY RELATIONS: THE EVOLUTION OF THE RELATIONSHIP BETWEEN IVECO AND ALPHA.**

Alpha is an automotive component company - belonging to a major European automotive group - which had been supplying IVECO since 1985. The main component supplied to IVECO - component A, the one which is investigated in detail in this paragraph- has always been critical for its relevance in the technical composition of the vehicle.

Until 1993, relations between IVECO and Alpha have been characterized by a mainly contractual approach, even though Alpha has been the only supplier for the specific component. With respect to design activities, IVECO has always given specific details of the component and Alpha has been mainly engaged in production. IVECO’s Suzzara plant received from Alpha’s plant in the North of Italy components supplied with daily deliveries by truck and had its internal unit dealing with the assembly of component A with other components.

With the renewal of the light range Alpha has been selected to join IVECO in the development of the new component A and in the supply of the component A as a single complete module rather than a single component to be assembled with other components before being installed in the vehicle. One of the main determinants of IVECO’s choice was Alpha’s competence in component A product development.

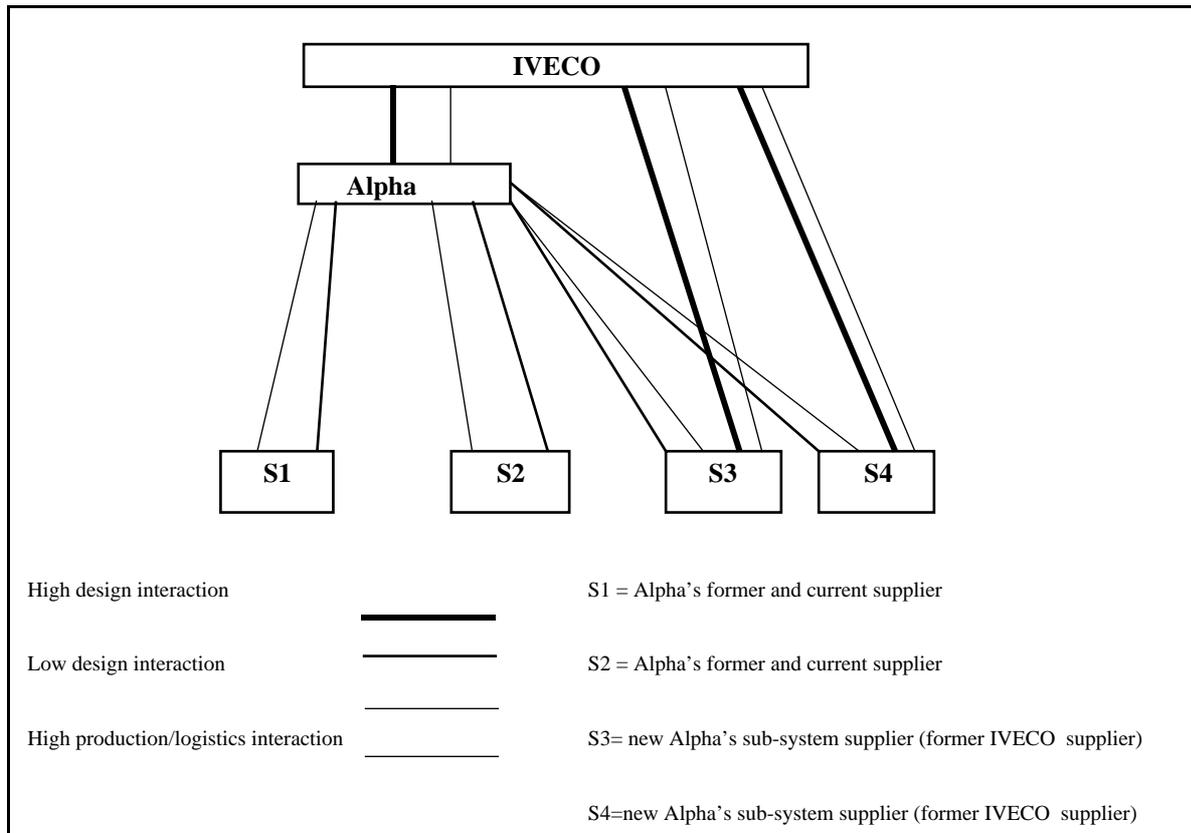
The bilateral relationship was to be developed along three main new dimensions. First, Alpha was to start co-design activities with IVECO. Second, Alpha was to supply a complete module rather than only component A; this would have implied that the value of component A was to increase by almost ten times compared to the value of the “raw” component A. Currently, the value of Alpha’s supply -including other components - to IVECO has increased by more than 200% and

represents one third of Alpha’s yearly turnover. Third, the new relationship had concerned also the production dimension: Alpha was to set up production units in Suzzara, Valladolid and a joint-venture in Brazil to supply the new IVECO-Fiat plant in Sete Lagoas. All these production units are completely dedicated to IVECO and all equipment in the Suzzara unit has been purchased for producing components to be installed on the S-2000 range.

The design process for component A has been both stimulating and difficult for IVECO. While IVECO’s initial plan was to put Alpha in charge of design and production activities of a complete module, the actual outcome has been a “team-based” design work comprising the effort by IVECO, Alpha and all suppliers of high value-added components to be assembled by Alpha in module A (Figure 2). While Alpha has been in charge for designing the “raw component A” in co-design with IVECO, the commercial vehicle assembler and the other suppliers have implemented co-design activities for the other components to be assembled within module A. Therefore, IVECO has played the role of design coordinator within the Module A team in the S-2000 platform, with one engineer in charge of dealing with each sub-system to be installed within module A. While sub-systems suppliers maintain property rights over their components, IVECO controls property rights over the raw component A. The main changes in the IVECO-Alpha design relationship is that product development activities are conducted together and that Alpha is in charge for all modifications.

The involvement in product development of module A has pushed Alpha to set up new organizational structures and increase its stock of technical and organizational competences in order to interact with IVECO and other suppliers within the S-2000 platform. First, a resident engineer in Torino has been in charge of dealing permanently with other counterparts. Second, Alpha has hired new engineers and technicians in order to conduct product engineering and process engineering activities; specific training has been implemented for personnel dealing with IVECO databases.

Figure 2. - "Module A" design and production/logistics network



Even though for other components Alpha's involvement has concerned mainly production volume issues, one of the main challenges for Alpha was to be able to develop technical competences sufficient enough to interact with other suppliers, given that the company had no previous involvement in product development activities for those components.

The new relationship between IVECO and Alpha is represented by the new Alpha production unit in Suzzara. This unit - highly integrated with Alpha information systems - is engaged in the production of component A and the assembly of other components which previously were shipped directly to IVECO's plant in Suzzara.

The setting up of the new production unit has required the development of new organizational routines. All production activities are closely linked with IVECO's production flows and are characterized by a higher reactivity when compared to the production activities in Alpha's plant in North Italy.

While before Alpha delivered components following monthly, weekly and daily plans sent by IVECO, the new production unit assembles and delivers modules A following also synchronous JIT, based on the matching between vehicle configurations and module configurations. Under an organizational dimension, Alpha has had to manage also the emerging international production network with new units in Valladolid (within the S-2000 project) and the new joint-venture in Brazil to supply the new FIAT-IVECO plant.

Within this new process configuration, Alpha has been facing two main inter-related tasks. The first one is the high degree of component variety and customization required by IVECO, combined with very short lead times. The second one is to guarantee an efficient management of second-tier supply flows. Alpha has been managing an increasingly complex supply network which is comprised also by major multinational companies, which are affected by the higher variety required by IVECO as well. In fact the new organizational framework is still in transition. Coordination of the

second-tier supply network is often managed jointly by IVECO and Alpha and such process has also been affected by the introduction of design modifications over time.

The setting up of the new production unit has required the acquisition and development of new organizational and technical competences. The new machinery and the assembly line are operated by very young newly hired workers and by technicians - mostly newly hired - who have spent one year training at Alpha's plant in North Italy while Alpha was conducting engineering and testing activities on component A prototypes. The production unit is managed by the senior commercial manager who has been in charge - and is still in charge - of commercial relations with IVECO over the years. Alpha's management has been highly motivated to foster commitment to the new bilateral relationships by both technicians and workers and to improve personnel's cooperative approach with IVECO's requests.

Managing the new bilateral framework has required a more intense cooperation between IVECO and Alpha. IVECO's and Alpha's technical and managerial personnel have increased their informal information exchanges to address problems affecting both partners. The whole management of module A supply is currently supervised by a Working Group within IVECO, with the involvement of Alpha. The main objectives of this team are quality improvement (in terms of both product and supply process) and costs reduction. Alpha has therefore been involved in internal problem-solving activities conducted by IVECO, such as in the case of component A documentation process within the ICP system.

Within the S-2000 project, IVECO and Alpha have entered a new phase of their relationship, which has three main new characteristics. First, a bilateral relationship has been transformed in a multilateral network, with IVECO and Alpha as main nodes within the network. This has required both companies to raise their organizational and technical competencies to manage the new vertical configuration. Second, both companies perceive the new relationship as irreversible. IVECO and Alpha have gradually increased their own commitment in developing the bilateral framework and a common feeling of trust, in order to be able to address efficiently common issues such as

modifications management and supply chain coordination. Such development has been also supported by the long-standing business relations between the two companies. The third feature is that both companies perceive the new bilateral framework as a relevant source for technical and organizational learning. While IVECO wishes to extend the IVECO-Alpha supply/delivery approach to other systems/modules, Alpha is willing to apply the emerging new organizational routines in other plants abroad and while setting up new partnerships with other customers.

### **Final observations and key-findings**

The analysis of the S-2000 project as a window on changes in final assemblers' and suppliers' knowledge management strategies suggests a number of considerations.

A general overview of findings highlights that IVECO's restructuring and knowledge management strategies while renewing its product configuration and organizational architecture seem to resemble paths implemented before by other automotive final assemblers. However, differences in timing could be explained by three distinct factors. In the first place, IVECO is a "new company" with respect to its business history. During the 80s IVECO has concentrated resources in developing a distinct identity and a common business culture. Only after ending such restructuring process, the company has been able to better absorb from the outside new business models and managerial practices, thus developing organizational learning patterns. In the second place, IVECO has been facing less external pressure in terms of market competition compared to car-makers. IVECO has maintained for many years more than 50% share in the Italian light vehicles market, and its share has started to slide below 50% later than FIAT Auto. The market success of the Daily vehicle might have delayed the undertaking of a deep renewal of the light vehicle range. In the third place, it could be argued that commercial vehicles have a longer life cycle compared to cars.

The latter consideration leads to a further interesting point which emerges from the empirical analysis. The IVECO case-study seems to suggest that commercial vehicles assemblers have to manage a higher degree of variety compared to car-

makers. To a certain extent commercial vehicles embody features which are common to industrial goods in the light of the typology of use and the degree of product customization. The introduction of a Common Language, that is, the PRP, has provided an internal “organizational routine” deemed to connect the internal network -from Marketing to Logistics- and to further integrate a renewed external network composed by suppliers, design firms and logistic operators. A high degree of customization combined with a high percentage of businesses as customers require commercial vehicles assemblers to adapt their product strategy, their organizational architecture and their marketing competences, as the establishment of Transolver and the acquisition of Fraikin by IVECO show.

With regard to knowledge management objectives and practices, summarized in Table 5, a preliminary assessment reveals emerging complementary and “homogeneous” dimensions between IVECO and Alpha in terms of technical and organizational competences to be developed, which apparently reflect the need to promote at the same time a growing division of labor on the one side and a higher degree of coordination on the other side.

Both IVECO and Alpha have focused on developing or acquiring specific technical competences. On the one side, IVECO is willing to gain competences in vehicle-related intangible services, therefore shifting forward into the value chain. It is apparent that IVECO is gradually accepting to depend on external know-how providers with respect to design and technological innovation. On the other side, Alpha is willing to play the role of innovation provider in its technological niche.

With respect to organizational aspects, IVECO and Alpha have attempted to develop new organizational routines in order to deal with their respective “regimes of variety”. While IVECO has implemented the new Product Representation Process and has changed production organization patterns, Alpha has had to adjust its internal organization to implement new delivery systems.

In order to facilitate the increasing integration between them, IVECO and Alpha have been attempting to develop increasing reciprocal

“homogeneity” or “correspondence” with regard to their technical and organizational competences.

Both IVECO and Alpha are committed to increase their system-level engineering competences which are highly necessary in the light of the emerging modularization of components. Such technical competences would allow both companies to improve their coordination roles at the different level of the supply chain and therefore to increase their ability to exchange knowledge flows with all the other network actors involved (design firms, other suppliers).

At the same time, the high degree of integration requires IVECO and Alpha to develop “homogeneous” organizational competences in order to achieve efficiency in coordination and information flows. This is apparent with regard to the requested ability for both companies in conducting team-work activities, promoting informal communication flows and encouraging a “partnership-based” approach towards each other. Another relevant field concerns the emerging “standardization” of supply chain management routines. In fact, IVECO’s objective is that Alpha, as a first-tier supplier, would increasingly take control of monitoring activities on second-tier suppliers by implementing criteria and behaviours to fulfill IVECO’s standards.

Within such emerging balance of technical and organizational competences between IVECO and Alpha, it is interesting that both companies have started and seem to have envisioned for their future the development of “architectural competences” in terms of product technology and configuration and organizational frameworks. Alpha seems to be developing “small scale” architectural activities, which are, however, carried on by IVECO rather than Alpha.

This preliminary empirical analysis of IVECO and Alpha in their transition to the “regime of variety” confirms the “cumulative” and “path-dependent nature” of the modernization and learning processes undertaken by automotive firms (Camuffo and Volpato, 1996: 813).

Table 5. - *Knowledge management practices and objectives –  
IVECO and Alpha - preliminary results*

	IVECO	Alpha
<i>Technical competences</i>		
Product	<p>Acquisition of Fraikin - a leading commercial vehicles renting company - in order to gain technical knowledge of vehicle-related intangible services;</p> <p>Increasing emphasis on internal development and/or external acquisition of system-level engineering competences;</p> <p>Increasing dependence on external know-how providers (suppliers, design firms) for system/component engineering</p>	<p>Increasing emphasis on internal development of higher technical competences and specialization on single component engineering;</p> <p>Increasing emphasis on internal development of system-level engineering competences.</p>
<i>Area-specific organizational competences</i>		
Production/Logistics	<p>Development of new routines and changes in layout to reduce production process complexity, manage vehicle variety and guarantee high levels of service towards customers (time to order)</p>	<p>Development of new routines and introduction of skilled personnel to improve “module A” variety management according to IVECO requests and guarantee higher levels of service towards IVECO (lead times)</p>
Purchasing	<p>Development of new routines to improve suppliers evaluation, selection and monitoring processes</p>	<p>Development of relational competences to interact with IVECO and second-tier suppliers with respect to deliveries and material flows.</p>
<i>Organisat. competencies</i>		
Intra-firm interaction	<p>Acquisition of external know-how and support in order to introduce a new Product Representation Process providing procedures to share a Common Language among Marketing, Engineering and Production/Logistics and Purchasing units;</p> <p>Introduction of organizational platforms and team-work approaches as new routines to facilitate inter-functional understanding and cooperation; Strengthening of team-based activities to improve internal information flows.</p>	<p>Strengthening of inter-unit cooperation and information flows to manage the emerging national and international production network IVECO-dedicated.</p>
Inter-firm interaction	<p>Introduction of organizational platforms and team-work approaches as new routines to facilitate co-design activities with suppliers and design firms;</p> <p>Strengthening of informal communication channels to improve information flows with external suppliers.</p> <p>Promotion of a “partnership” business culture toward suppliers within all functional/operational units</p>	<p>Appointment of a resident engineer and development of IT dedicated competences to foster information flows with other actors within the S-2000 platform;</p> <p>Strengthening of informal communication channels to improve information flows with IVECO;</p> <p>Promotion of a “partnership” business culture toward IVECO within all functional/operational units</p>

The achievement of the S-2000 project objectives in terms of knowledge development set up by the top management seems to have been slowed by the partial resistance of functional units to increase cooperation and information flows, by the rigidities of specific routines hard to modify and by the gradual process of knowledge development and acquisition. The development of “project managers” with multidisciplinary and multitask skills within organizational platforms, functional units and operational units seems to represent one of basic strategies to make IVECO able to shape and implement its new roles.

A similar assessment concerns Alpha, which has been attempting over time to increase its stock of technical and organizational competences and to set up a bilateral relationship with IVECO increasingly based on trust and less on exchange of “hostages”. It is interesting that both IVECO and Alpha have introduced young and trained personnel

to run business activities and plant equipment within the new product and process configuration.

Lastly, it is deemed necessary to focus future research - concerning knowledge management strategies - on three main areas. First, it is still not clear to what extent first-tier supply networks are undertaking rationalizing processes and which is the emerging balance between first-tier and second-tier suppliers’ knowledge management strategies. Second, it is deemed interesting to develop further the analysis of changes in knowledge management strategies within a global sourcing perspective. The third line of research emerges from the empirical analysis developed in this paper. It seems necessary to explore deeper possible differences in managerial terms between car-assemblers and commercial vehicles assemblers, and assess whether such differences - if any - have caused different patterns in terms of knowledge management strategies.

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