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Between Internationalisation and Proximity: the internationalisation process of automotive first tier suppliers

Vincent FRIGANT

GREThA UMR CNRS 5113

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GRETHA UMR CNRS 5113
Université Montesquieu Bordeaux IV
Avenue Léon Duguit - 33608 PESSAC - FRANCE
Tel : +33 (0)5.56.84.25.75 - Fax : +33 (0)5.56.84.86.47 - www.gretha.fr

Entre internationalisation et proximité : le processus d'internationalisation des équipementiers automobiles de premier rang

Résumé

L'article cherche à analyser les stratégies d'internationalisation des équipementiers de premier rang de l'industrie automobile. Le développement de la production modulaire implique une transformation des relations verticales interfirmes dont nous cherchons à comprendre les effets sur le processus d'internationalisation des équipementiers automobiles. L'article explique les formes d'internationalisation de ces firmes par le biais d'une grille d'analyse où la contrainte de proximité est conçue comme une fonction de la complexité et du degré d'exclusivité des interactions interfirmes. L'article est structuré en trois parties. La première examine les transformations induites par la modularisation de l'automobile. La seconde présente quelques faits stylisés sur l'internationalisation des équipementiers. La troisième propose une grille d'analyse des interactions interfimes et en montre les implications en termes de choix de localisations pour les équipementiers.

Mots-clés : Internationalisation ; Modularité ; Géographie industrielle ; Relations verticales ; Equipementiers de premier rang ; Automobile

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Abstract

The paper analyses the strategies of internationalization pursued by first tier automotive suppliers (FTS). The advent of modular production in this sector implies many changes in vertical relationships, which can in turn be used to explain the causes and forms of suppliers' internationalization. The paper tries to explain internationalization patterns via an analytical grid wherein proximity needs are portrayed as a function of the complexity and exclusivity of inter-firm interactions. The argument applied in this article is broken down into three sections: the first reconsiders the transformations induced by modularization; the second presents some stylized facts about the internationalization of FTS; and the third part both presents an analytical grid and derives its implications in terms of location of suppliers.
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Key words: Internationalisation; Modularity; Industrial Geography; Vertical Relationships; First Tier Suppliers; Automotive

JEL : L62; R3 ; F23

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1. Introduction

Over the past few years, the feeling has grown that the sharp rise in world trade is largely a reflection of increased trade in intermediary goods. After a phase during which internationalisation mainly signified a search for new end users, production process disintegration is now thought to have become the main factor behind firms' internationalisation (Feenstra, 1998). In a recent study on the situation in the US, Burke, Epstein and Choi (2004) spotted a rapid jump in foreign-sourced goods' share of total manufactured inputs (from 12.4% in 1987 to 22.1% in 2002). The same evidences are true for other countries like France (Miotti, Sachwald, 2006; Fontagné *et alii,* 2004). Macro-economic outcomes of this kind have strengthened the hypothesis that what we are witnessing is a deep-seated reorganisation in global sourcing networks. Large firms from the world's developed countries seem to be amplifying the international division of labour by mobilising production sites in different countries, depending on which absolute or comparative advantages they seek (Berger, 2005). It also appears that this movement has gone beyond simple production goods to encompass certain service activities, including some that are development and engineering-related (Levy, 2005).

This movement, which is readily identifiable at a macro-economic level, suggests that value chains are fragmented into a multitude of internationally dispersed entities. In what could be a sign of the wealth of studies on this topic and/or the complexity of the issues involved, a whole host of terms have been forged in recent years to evoke this phenomenon, ranging from "delocalisation" (Leamer, 1996) and "slicing the value chain" (Krugman, 1996) to "offshoring" (Levy, 2005). Kleinert (2003) writes of three simultaneous forms: Global Sourcing; Outsourcing; and MNE Networks. Behind these many terms, we note that there are two ways of internationalising a value chain, depending on whether one is reasoning at the intra- or the inter-firm level. On one hand, internationalising a value chain means relying on foreign subcontractors. This is what Kleinert calls Global sourcing. Modalities can differ here, depending on the nature of the role(s) being delegated to the subcontractor operating at the buyer interface (Andersen and Christensen, 2005). In addition, internationalisation can stem from a division of labour that is internal to the firm trying to organise its own production and R&D entities at an international level in such a way as to maximise the advantages it derives from each of its localisations (eg. Fields, 2006).

The present article focuses on this second way, intra-firm form of value chain internationalisation. Two reasons justify this choice. Firstly, empirical estimates have shown that intra-firm trade accounts for a large proportion of all international trade. This makes it all the more interesting to understand how firms organise their internal division of labour internationally. Secondly, the overall trend has made it all the more crucial that firms establish development activities in low-cost countries – despite the general consensus that activities of this sort are supposed to remain within the developed world, and even inside of well-defined clusters (Porter, 1998). Indeed, due to untraded interdependencies and knowledge-stickiness problems (Storper, 1995; Dicken and Malmberg, 2001), the workforce used for such activities is supposed to be a qualified one. Given the challenges that developed countries would face were this clusters hypothesis to be validated, it behoves us to study what justifications might be given for decoupling development and production activities.

The question can therefore be reformulated as follows: how can we best explain a multinational's structuring of an international division of labour amongst its varying entities? An initial element of response consists of affirming that trends like trade liberalisation, the development of IT and lower transportation costs have already eliminated obstacles to production process disintegration. We do not feel, however, that this argument is sufficient in and of itself (*cf*. Macher *et al.*, 2002). Our hypothesis is that production process fragmentation derives upstream from a technical-organisational change in the value chain.

As a result, the present article will attempt to study whether modularity constitutes a factor capable of explaining assembly industry internationalisation. We will notably be asking whether modularity alters assembly industries' geography, and if modular production encourages value chain internationalisation by alleviating knowledge-stickiness problems. Consideration will also be given to the opposite question, which is whether modularity creates new proximity needs whose effect is to reduce value chain internationalisation possibilities.

The hypothesis that modularity might explain changes in industrial geography seems to be a relevant one since many studies have already stressed that modularity leads to a reconfiguration in the division of labour (Baldwin and Clark, 2000). Of course, there is an ongoing debate about modularity's organisational impact on the borders of the firm, or on supplier network management. A fracture can be observed between (Frigant, 2005):

- Studies averring that modularity leads to a profound refocusing of the firm on its core competencies, thus enabling an arm's length relationship between suppliers and buyers (Sanchez and Mahoney, 1996; Langlois, 2003; Sturgeon, 2002);
- Authors opining that firms who are part of a Complex Product System (CoPS) should maintain a broad range of competencies internally, and that relational coordination remains an efficient way of managing a supplier network (Brusoni and Prencipe, 2001; Brusoni, Prencipe and Pavitt, 2002; Prencipe *et al.*, 2005).

Beyond their varying conclusions, however, these two approaches do converge to stress that, as an innovation, modularity creates organisational and strategic transformations for buyers and their suppliers. This raises a question as to whether modularity comprises the origins of a new geography of inter-firm vertical relationships. If so, what is this geography?

To try to answer this question, we will concentrate on two refocusing movements. The first is sectorial in nature. As far as we are aware, the present paper's treatment of this topic in the automotive industry context is unprecedented. Preceding studies on the geography of modularity have mostly studied the electronics and IT industries (Ernst, 2002; Lüthje, 2002; Sturgeon, 2003; Gangnes and Van Assche, 2004 van Egeraat and Jacobson, 2005; Fields, 2006). Their commonly shared conclusion has been that modularity enables a decoupling of production and design activities as well as a deepening of production process disintegration. They have also maintained that not all production activities are delocalised, since some require proximity or else do not benefit from competitive advantages even when there is a move to low-cost countries. In fact, the idea advanced by these studies is that design activities are likely to remain concentrated in those clusters where the modular architectures are actually being designed. By choosing the automotive industry, we will ascertain whether these main conclusions continue to be valid in this branch, which may be well advanced along a modularisation process but is not as modular other sectors, despite being classified as a CoPS (Sako, 2003). Best (2003) has already done some work along these lines, averring that clusters are meant to last. The present paper would like to expand upon this perspective by focusing on a particular type of firm.

This is because the second refocusing movement consists of not considering the branch as a whole but instead of specifically highlighting a particular type of firm - first tier suppliers (FTS). Carmakers have, after all, already received great deal of attention. We know of a whole host of analyses delving into their localisation logics and internationalisation motives. Generally a link is made with carmakers' market access strategies and attempts to surmount entry barriers, their aim being to achieve production site regionalisation (Carrillo *et al.*, 2004; Freyssenet *et al.,* 2003; Humphrey *et al.*, 2000). There is also the fact that the FTS have sought to publicise modularity's advent in the automotive sector. Carmakers operate towards the top-end of the value chain, meaning that suppliers are the ones most directly affected by the shift to modularity (Becker and Zirpoli, 2005). Firms' internationalisation may be generally recognised at the level of the end user interface, but few studies have focused on intermediary goods producers' internationalisation strategies. Yet we sense that these strategies are actually grounded in a peculiar logic. For instance, studies on the geography of modularity in the electronics industry have revealed that Electronics Contract Manufacturers constitute vectors production internationalisation in this sector (Gangnes and Van Aasche, 2004; Sturgeon, 2003; Lüthje, 2002).

For this reason, the present article focuses on the internationalisation strategies that automotive first tier suppliers have been pursuing, and generally questions the way in which the shift to modularity has led (or not led) to the creation of new forms of proximity between supplier and carmaker entities. It relies on our analysis of 30 of the world's largest FTS (as defined by 2002 revenues) and is a mainly qualitative analysis that consists of studying the localisation of such firms' production and development sites, as well as any recent changes therein.

The article is organised into three sections. The first explains organisational changes in the automotive industry and tries to raise understanding of which new activities come under first tier suppliers' purview. We highlight the development of modular production as a vector that serves to structure this industry. The second section is based on stylised facts about the main trends in supplier internationalisation. The third explains why this internationalisation is grounded in the foreign expansion of production and development sites. Our explanation of FTS spatial dispersion relies on a two-step approach, the first involving a study of the forms of coordination that modularity induces, the second deducing the forms of proximity that derive from this. Such an approach helps to explain the nature of the activities being internationalised; which ones remain in the national space; and the choice of locations.

2. Reconfiguring inter-firm vertical relationships in the automotive sector

Automobile production is a complicated thing to do, at two different levels at least. It involves designing a complex product that is the combination of many components and which mobilises dissimilar technologies. Moreover, given the fact that this occurs within a mass production regime, it also involves interlinking a mass of information flows and materials. Ever since Ford, carmakers have faced significant cognitive and productive coordination constraints and resolved them in varying manners depending on the period in time and carmaker in question[1] (Boyer and Freyssenet, 2002). Irrespective of the solutions attempted,

[1] To get an idea of this, we can contrast an advanced vertical integration model à la Chandler (1977) like the one initiated by Ford Motor Company, with the implementation of a captive network of specialised suppliers, as is the case in Japanese keiretsus (Aoki, 1988).

the common objective has been to ensure a close coordination of the value chain by managing the systemic complexity of the product being manufactured (Clark and Fujimoto, 1991).

Over the past few years, the automotive industry has committed to a new technical-organisational orientation in its efforts to manage complexity: modular production, a.k.a. modularity. Widely present in hi-tech industries like semi-conductors (Langlois and Robertson, 1992) or IT (Badwin and Clark, 2000; Sturgeon, 2002) and also in certain traditional sectors like bicycles (Galvin and Morkel 2001), modularity has opened a new stage in the history of vertical relationships in the automotive industry. It has led to a radical reconfiguration of the diptych that is the technical vs. the inter-firm division of labour. The borders of carmaker and supplier firms are being rearranged, forcing the latter to redefine their own strategies.

2.1. Principles and advantages of modularity

In its basic principle, modularity entails an approach where the intent is to break complex systems down into their constituent parts (Simon, 1962). From a technological point of view, this involves decomposing a final product and rearranging it into a series of sub-assemblies that interconnect via standardised interfaces. The image here is of a game of Lego®, with each piece being a module featuring standardised interfaces that people can assemble in any way they choose to create a complex system, irrespective of the shape of the element in question. Modularity can allow for a broad array of assembly possibilities, as long as there has been a clear definition of the form of each module (and above all, of its interfaces). The approach is clearly more complex with industrial products, which start out with an end result (a final product that is supposed to be a complex system) and then go on to define the modules involved, as well as their interactions, in a way that allows them to achieve (a series of) global functionality(ies).

In short, modular architecture has turned out to be a powerful way of reducing product-systems' complexity. This is done by organising the breakdown of a system into sub-systems that are autonomous and independent (insofar as they can be developed and pre-assembled separately) and interconnected via relatively stable interfaces. This decoupling of interfaces means that a module can be altered without any other modules necessarily having to be modified, or without the product as a whole having to be redefined (Ulrich, 1995).

This dissociation between the whole and its constituent parts is central to modularity's economic advantages, be it towards the upstream or downstream side of the product lifecycle. Once the architecture has been stabilised, incremental innovations become easier to achieve since they only touch upon certain modules. It even becomes possible, as is the case with electronic products, to redefine certain *ex post* product characteristics in a way that reflects the different kinds of demands being expressed in the marketplace (Langlois and Robertson, 1992). Modularity also makes it easier to accommodate heterogeneous demand by differentiating supply through the differential structuring of the modules' varying layers (Schilling, 2000). Moreover, since the basic architectures are widely shared, supply differentiation becomes cheaper, with economies of scale and scope being generated through a proliferation of shared components, especially when such components have survived from one product generation to the next. On the downstream side, end users can improve modular products by replacing their technically outdated components (hardware upgrading). They can also reduce maintenance and repair costs by simplifying handling operations, thus cutting the costs of any components they need to change (Ulrich, 1995).

These advantages pertain to the market relationship, but the dissociation in question also alters the product's actual manufacturing. For example, it is possible to work in a parallel and relatively autonomous manner on various modules during their design phases. This helps to reduce time-to-market and cuts design costs (Ulrich, 1995; Baldwin and Clark, 2000). A crucial point for modularity is that it enables a widespread re-utilisation of technologies that were already deployed in the past, thereby decreasing the intensity of problem-solving procedures. Development actors can draw from catalogues of components that have already been imagined, tested and approved, the purpose being a more incremental type of product evolution (Garud and Kamaraswany, 1995). In their industrialisation phase, modules can be produced separately, and even by different firms. This means that assembly lines are reduced to mere integrators of pre-assembled modules. Lastly, after-sales service can be more readily delegated to the entity in charge of manufacturing any module that is defective – which is relevant for parts storage and repair call-outs.

In short, modularity's varying qualities have significantly extended the opportunities for dividing work amongst different tasks (design, production, maintenance) and within each task (working separately on each module's design, separate production of different modules that are then assembled during a final integration work). In this sense, modularity is portentous of a deeper inter-firm division of labour (Langlois, 2003; Sturgeon 2002; Baldwin and Clark, 2000; Sanchez and Mahoney, 1996). This is because the final assembler benefits from a greater intra- and inter-division of tasks and can refocus on basic competencies like overall architecture design and the modules' final integration. This is the path to which most carmakers have committed, and in turn this has brought about a transformation in auto suppliers' status.

2.2. The key role played by first tier suppliers in the automotive sector's adoption of modularity

Carmakers' refocusing on architecture has meant that at an industry-wide level what we are witnessing is the emergence of actors capable of assuming new development, production and organisation responsibilities towards the branch's upstream side. As emphasized by Steinmueller (2003), the establishment of a new intra-industry division of labour means that suppliers (older ones and new entrants) have developed competencies that allow them to believe in their own ability to undertake these recently externalised tasks.

As such, the hardening of the sourcing pyramid that was initiated in the 1980s, and which led to a dramatic fall in the number of suppliers in direct contact with carmakers (Gerpisa, 2002), offers a backdrop to the current phase (Lung and Volpato, 2002). The sourcing pyramid's rationalisation resulted in the branch's first generalised reshuffling, leading to the emergence of a category of first tier suppliers (FTS) that has become one of the main actors in this value chain. FTS were forced during this initial phase to develop their technological, organisational, material and immaterial means and competencies. They soon tried to apply these resources profitably by getting carmakers to expand their own externalisation drives so as to include modularity (Frigant and Talbot, 2005).

For many observers, the shift to modularity has initiated a new phase in vertical relationship practices, engendering a new generation of so-called "0.5" tier suppliers (Volpato, 2004). Of course, to avail themselves of this new status, suppliers have once again had to enhance their competency levels, this time along four different lines (Fourcade and Midler 2005; Lara *et al.*, 2005).

First of all, greater module design responsibilities have forced suppliers to augment their R&D competencies. In modularity's more advanced configurations, suppliers use functional specifications as a basis for proposing a complete architectural and technical solution for any module that may be crucial to a future vehicle. This has led to more resources being devoted to research, and at the same time to an increase in the number of staff members working as researchers and engineers.

Secondly, modules, as complex functional sub-assemblies, are akin to combinations that mobilise a wide range of technologies and professions. Questions have arisen about professional specialisation, for example, long considered by suppliers as a basic organisational principle. Becoming a modular-supplier requires a mastery of dissimilar technologies, i.e., a broadening of one's scope of competencies. This can mean combining a plastician's job with an electrician's, a specialisation in hydraulics with one in electronics, etc. Even more importantly than FTS' increased R&D expenditures is the fact that they are being forced to acquire any and all requisite competencies before their potential competitors do, because they want to be in a position to respond to (or else anticipate) carmakers' calls for tender. This has resulted in two major trends: acquisitions; and strategic alliances concocted together (or else designed in collaboration) with companies offering complementary competencies. The generalisation of electronics and increasingly stringent environmental rules have helped to amplify this need to expand the scope of one's competencies due to the fact that technological change affects (almost) every module.

At the same time, rising delegation means that today's modular suppliers both manage other suppliers (as part of a vertical relationship) and collaborate with other modular-suppliers (within a horizontal collaboration framework). When FTS integrate a module's constituent sub-assemblies and components, they are piloting a network comprised of many suppliers and upstream partners. This leads to a rise in transaction and (internal) governance costs, plus in R&D spending, since second tier suppliers often lack relevant competencies – an obstacle with repercussions at the productive stage. Modular-suppliers are asked to ensure the reliability of the whole of the value chain, ranging from their own sourcing to the delivery of modules to clients. To ensure the lower tiers' complete integration into the delivery chain, FTS have had (and still have) to develop competencies in areas like project management; purchasing and sourcing; engineering and quality techniques; and logistics.

Lastly, the scope of inter-FTS competition has also changed. Suppliers' competitiveness depends increasingly on their ability to offer a complete and innovative range of modules. By a complete product offer, we include the ability to develop and produce modules construed as autonomous products, and also to offer ancillary services (delivery, process-contingent product finalisation, after-sales service to end users, etc.). Where a carmaker pursues a platform logic[2], suppliers need to be able to manufacture and deliver modules to all of its plants across the world. As for an innovative product offer, this means the ability to anticipate carmakers' specifications by devising innovative solutions. For suppliers, this entails engineering new functionalities and monopolistic innovation situations on carmakers' behalf. Today, innovations affecting a car's "options" are created in suppliers' own design departments. Which is not to say that return costs have been rendered obsolete: the QCD (quality-cost-delay) triptych is still relevant and continues to complexify suppliers' accounting calculations, which are still solved by variables like economies of scale and scope or by the ability to generate increasing yields.

[2] This involves developing different car models based on a shared architecture.

Changes in FTS' status have opened up a whole new field of constraints and opportunities. The former include the redefinition of firms' borders, both in terms of the activities they conduct and the range of competencies they need to master. At the same time, new opportunities have arisen for new entrants (one example being Siemens, the electronics firm that has in just a few years become a major supplier to this sector) or for existing firms to break through or to reinforce their current market position. Modular production helps to reshuffle the cards amongst FTS. Continuing as a modular-supplier, or becoming a successful one, means adopting a clear redeployment strategy, thus being able to change the scope of one's portfolio of activities or one's target customers. Internationalisation is one modality for achieving this end.

3. FTS' increasing internationalisation

3.1. Stylised facts about suppliers' internationalisation

Without getting into a long, drawn out description of FTS internationalisation (Kamp, 2006; Gerpisa, 2002; Gerpisa, 1999), we can characterise this process via three main stylised facts.

The first concerns rising sales abroad (commercial dimension). Underlying this form of internationalisation is FTS' need to increase sales volumes so as to restore profitability. Current adaptations have weighed on FTS' fixed costs whilst causing a more than disproportionate rise in variable costs. Suppliers who are strongly committed to a modular strategy have suffered declining profitability over the past few years, being squeezed between rising costs and the desire to preserve profit margins[3]. The solution for all firms has consisted of increasing sales volume by applying two policies. The first involves supplying the greatest possible number of models to specific carmakers, in a single sourcing logic based on deeper bilateral relationships. Unfortunately, this runs counter to carmakers' desire not to depend on a single supplier (although it does mesh relatively well with their platform policies and module commonalisation practices). A complementary solution is to broaden one's customer portfolio by being referenced by an ever-greater number of carmakers. Both of these policies have led to a rise in the proportion of foreign sales. For the first policy, this is because suppliers follow carmakers that are embarking upon their own internationalisation drives; for the second, it is because they themselves are trying to capture new foreign customers. The trend is easy to discern if we consider a sample of the world's 30 largest suppliers[4].

Three indicators are used to estimate FTS internationalisation (see Table 1).

- A static indicator measuring the degree of internationalisation in 2002 and representing the proportion of foreign sales (see Table Notes);

[3] This means that certain suppliers have experienced, and are still experiencing, serious problems. In 2005 alone, Collins & Aikman operated from the month of May onwards under U.S. Bankruptcy Code Chapter 11 protection (selling almost all of its non-American activities in December of that year). From September 2005 onwards, Delphi also put its wholly-owned US operating subsidiaries under Chapter 11 – and in that same month, Visteon announced the transfer of 23 facilities to a Ford-managed entity called Automotive Components Holdings.

[4] The empirical elements contained in the present study rely on corporate data compiled on 30 of the world's biggest FTS, determined by their 2002 automotive revenues (as ranked in *AutomotivesNews*). We have compiled financial data; data on operational entities; and elements that are more qualitative and organisational in nature.

- A static comparative evaluation of this rate (including changes in different zones' sales performance)
- Lastly, a foreign sales growth rate, in value, between 1998 and 2002.

Since 1998, foreign sales have generally represented automotive FTS' most dynamic growth driver. If we break these actors' sales geography down by major zone, what we discover is that suppliers' foreign sales rose by 27.7% between 1998 and 2002, a dynamism translating their increasing dependency on foreign markets. Despite inter-FTS variances (whose explanation is somewhat irrelevant to the present study)[5], these indicators exemplify the rise in FTS' commercial internationalisation.

The second stylised fact pertains to the global space's productive fabric. Published documents are disparate in terms of their precision and diffusion, making it hard to identify groups' foreign entities. Nevertheless, Table 2 does offer three series of indicators for the year 2002. The first covers the number of FTS entities, and the number of countries where they are located. The second pertains to employees abroad as a proportion of total staff numbers. The third relates to the distribution of physical assets as booked in companies' annual reports. Although these three indicators are not entirely identical, they do reveal suppliers' maintenance of a significant foreign presence.

This point becomes particularly visible when we consider the number of entities, or number of countries where suppliers are present. With the exception of AAM (which in sales terms is one of the least internationalised suppliers), FTS declare a presence in more than 10 countries. The mode is around 25 countries, but this can exceed 30 for the most internationalised firms (37 for Delphi, 33 for Lear, 32 for Autoliv, just considering FTS that work in the automotive branch alone). As for the number of entities run internationally, this often exceeds the 100 mark, with companies declaring an average of 151 such entities, the mode being 185[6]. Even when we limit this to production entities alone, the sites' international nature remains obvious. The distribution of group staffing confirms this impression, with foreign employees accounting for 61% of all 2002 staff on average. Despite significant inter-firm variations, notably for the more diversified groups, this preponderance of foreign employees confirms that firms frequently organise themselves according to a global space interlinkage logic. The same can be said when we use a long-lived asset distribution indicator (or something similar) on firms, since a high percentage of all such assets are located abroad.

[5] Several indicators are especially useful to consider here. A relatively weak static rate of internationalisation can come with strong growth in foreign sales (i.e., Faurecia), whereas a fall in this rate can mask an explosion in domestic sales, even in a context marked by strong growth in global sales (Siemens). Only TRW and Magnetti-Marelli experienced a simultaneous fall in foreign sales (in value) and in degree of internationalisation. Note that these two FTS suffered serious economic problems during the period under study.

[6] We take the minima each time, and have excluded Toyada Gosei in the present instance.

Table 1. The internationalisation of sales – 1998-2002

FTS	Country	Total automotive parts sales to global carmaker (2002, $billion)	Degree of internationalisation 2002, in % (1)	Growth rate in degree of internationalisation 1998-2002, in % (2)	Foreign sales growth rate 1998-2002, % (3)
Delphi	USA	25,527	23	1.4	4.7
Bosch	Germany	19,085	38	18.8	29.1
Visteon	USA	16,900	28	11.5	29.0
Denso	Japan	15,348	38	15.1	36.2
Lear	USA	14,400	34	-4.3	20.1
Johnson Controls	USA	13,653	43	12.3	52.8
Magna	Canada	12,188	32	-7.9	33.0
Aisin	Japan	10,716	15	-3.7	17.5
Faurecia	France	10,000	15	11.3	231.7
TRW	USA	9,900	50	-2.0	-3.9
Valeo	France	8,787	39	12.9	21.4
Siemens VDO Auto	Germany	8,500	30	-2.9	71.9
Dana	USA	7,315	27	6.4	6.2
ZF Friedrichshafen	Germany	7,157	34	13.2	92.4
ThyssenKrupp Auto	Germany	6,218	57	-13.2	26.2
ArvinMeritor	USA	5,850	41	3.3	15.7
Continental	Germany	5,600	40	-3.4	50.4
Du Pont	USA	5,400	50	33.3	73.8
GKN	UK	4,733	62	39.7	72.0
Michelin	France	4,650	56	12.0	19.2
Autoliv	Sweden	4,443	50	10.7	34.5
Collins & Aikman	USA	3,886	19	-1.3	45.9
AAM	USA	3,480	4	2.2	70.3
Goodyear	USA	3,200	52	-6.7	0.9
Freudenberg	Germany	3,000	62	0.0	-20.5
Federal Mogul	USA	2,999	52	2.0	9.4
Tower Auto	USA	2,754	25	21.4	543.9
Toyoda Gosei	Japan	2,704	25	6.7	41.4
Magneti Marelli	Italy	2,674	21	-2.7	-9.4
Behr	Germany	2,616	33	21.2	87.0

Note: Here, and as is customary in the automotive business, "domestic" is used in the broader sense of the term, corresponding to regional integration areas (North America, Europe, Asia). This leads to an under-estimation of the degree of internationalisation in the sense of the Nation-State. (1) corresponds to the relationship between foreign and total sales. (2) expresses the preceding factor's growth rate based on an average calculated over 2 years (1998/99 and 2001/02) to limit the effect of any aberrant fluctuations. (3) The foreign sales growth rate is also calculated by taking average sales over two years (1998/99 and 2001/02).

Source: Authors' calculations based on AutomotivesNews database

Table 2. The internationalisation of production

2002	Number of facilities (production+R&D)		Proportion of foreign employees (%)	Proportion of long-lived foreign assets (%)
FTS	Countries	Facilities		
AAM	6	19	na	27.6
Aisin	13	58	na	15.6 (1)
ArvinMeritor	27	150	na	47.1
Autoliv	32	98	90.9	na
Behr	15	30	56.1	na
Bosch Automotive	29	>100	55.6	na
CollinsAikman	15	121	na	44.0
Continental	17	na	57.9	na
Dana	30	200	na	38.8 (2)
Delphi	37	296	na	39.7 (4) (outside USA+Canada)
Denso	31	183	na	31.2 (1)
Du Pont of Nemours	>70	210	na	37.7 (3)
Faurecia	26	230	58.2	60.2 (4)
Federal Mogul	25	220	na	58.3 (4)
Freudenberg	43	122	58.7	Na
GKN	na	na	67.3	Na
Goodyear	29	90	na	44.5
Johnson Controls	28	260	na	43.6
Lear	33	280	69.6	53.8
Magna	>22	253	72.3	72.4 (5)
Magneti Marelli	16	73	77 (2003)	Na
Michelin	19	86	na	44.7 (outside Europe)
Siemens	30 (VDO)	around 130 (VDO)	na	62.1 (6)
ThyssenKrupp Auto.	na	120	72.0 (7)	Na
Tower Automotive	15	60	na	33.0 (outside USA+Canada)
Toyoda Gosei	13	23 (outside Japan)	na	24.7 (1)
TRW	23	185	60.5	66.4 (2003)
Valeo	25	203	34.1 (outside Europe)	Na
Visteon	25	185	na	41.3 (4)
ZF Fried.	25	119	36.7	Na

Notes: (1) Calculated from assets before consolidation (2) DCC is not affected

(3) Net property. These figures are for the Pont de Nemours group (where Automotive accounts for 20% of group sales)

(4) Net Property (5) Fixed assets, net

(6) Siemens Group. Before eliminations and without financial activities, Siemens VDO (Siemens auto branch) accounts fo 9.7% of Siemens sales and 10.7% of its employees

(7) ThyssenKrupp Automotive accounts for 20.1% of total TK employees

na: not available

Source: Annual Report-Enterprises

These findings call for two comments. Firstly, internationalisation has not led to any real delocalisation trends per se. Suppliers have maintained a plethora of production sites in their countries of origin. Furthermore, R&D sites remain largely situated in said countries. The norm consists of maintaining big R&D centres in one's country of origin, and setting up ancillary development centres in the main automobile-producing countries (Germany, USA, France and even Japan, a country that suppliers still find hard to access). Alongside of this,

FTS run many "technical centres" whose purpose is to ensure technical co-ordination with their customers' local entities. The past few years have witnessed a duplication of foreign R&D centres - but once again, there has been no concomitant reduction in the number of staff members working in firms' countries of origin. Furthermore, when staff numbers are compared with the number of entities, what becomes apparent is that said entities are really quite small in size. The supplier industry is not characterised by large productive complexes in the same way as carmakers are, which makes it much harder to analyse the activities being undertaken in these entities, even if intuitively ones gets the sense that the forms of internationalisation found here are based on a simultaneous pursuit of varying logics.

This third stylised fact is that this fragmentation of sites is directly linked to firms' target markets. Clearly there has been an overlapping in productive and commercial spaces' internationalisation.

We can approximate this phenomenon by analysing an instrument that FTS like to deploy in an attempt to expand their capabilities during their internationalisation drives: partial and majority takeovers. From January 1989 to July 2003, our 30 FTS undertook a total of 953 such operations. Sorting this data according to suppliers' nationality of origin and target countries confirms two outcomes. Firstly, firms' country of origin remains their priority destination. Explanations can include their superior knowledge of opportunities at home; the search for complementary competencies; and a desire to achieve critical size in one's domestic market. This brings us back to the preceding idea that productive internationalisation does not exclude the maintenance of a national productive apparatus. Secondly, the main foreign countries being targeted are all (with the exception of Switzerland, see Table 3) automobile-producing countries. This denotes a clear goal of wanting to assume or reinforce productive positions in those spaces where potential customers can be found.

Table 3. Number of Mergers & Acquisitions by nationality of origin/destination between 1989 and July 2003

(Five leading target countries)

Canada	***n=1***	***France***	***n=3***	***Germany***	***n=7***	***Italy***	***n=1***
Germany	12	Germany	10	Germany	139	France	3
United States	10	United States	9	United States	81	Italy	3
Canada	7	France	8	United Kingdom	42	Brazil	3
Austria	5	Japan	5	Czechoslovakia*	19	Germany	2
United Kingdom	3	South Korea	4	Switzerland	16	Portugal	2
Japan	***n=3***	***Sweden***	***n=1***	***UK***	***n=1***	***USA***	***n=13***
Japan	11	Japan	6	United Kingdom	25	United States	77
United States	6	United States	4	United States	22	Germany	23
China	3	Sweden	4	Germany	13	United Kingdom	19
Italy	2	France	3	India	4	Italy	12
India	2	Thailand	2	Italy	3	Japan	9

*Note: * Czech Republic and Slovakia combined. n = number of suppliers with that particular nationality*
Data compiled at the group level and not the automobile subsidiary level.

Source: Authors' calculations based on Platinum (Thomson Financial) database

Similarly, cartography of the sites we have been able to map for certain FTS confirms that suppliers have been setting up operations in spaces they hope to supply (Appendix). This

often coincides with an increase in exports[7], but the fact remains that the essential modality for capturing a new foreign market is to establish a productive facility in a space that is contiguous to it. The real question then becomes one of determining the economic foundations upon which such internationalisation is based, since the protectionist argument is not sufficient. Yet even as FTS mainly use acquisitions to reinforce their positions in automobile-producing countries, they continue to build facilities in non- automobile-producing countries. Using Greenfield investments, FTS are developing productive bases in countries featuring low production costs. In other words, logics other than market vicinity are also at work – hence the plurality of reasons given for corporate internationalisation. By highlighting three different logics, we are developing a basis for subsequent analysis of the forms of proximity that FTS seek to establish.

3.2. The threefold logic underlying productive internationalisation

Beyond the convergent elements highlighting FTS' further internationalisation we can try to specify the logics underlying their approaches by analysing the trajectories of the entities involved in production and R&D activities.

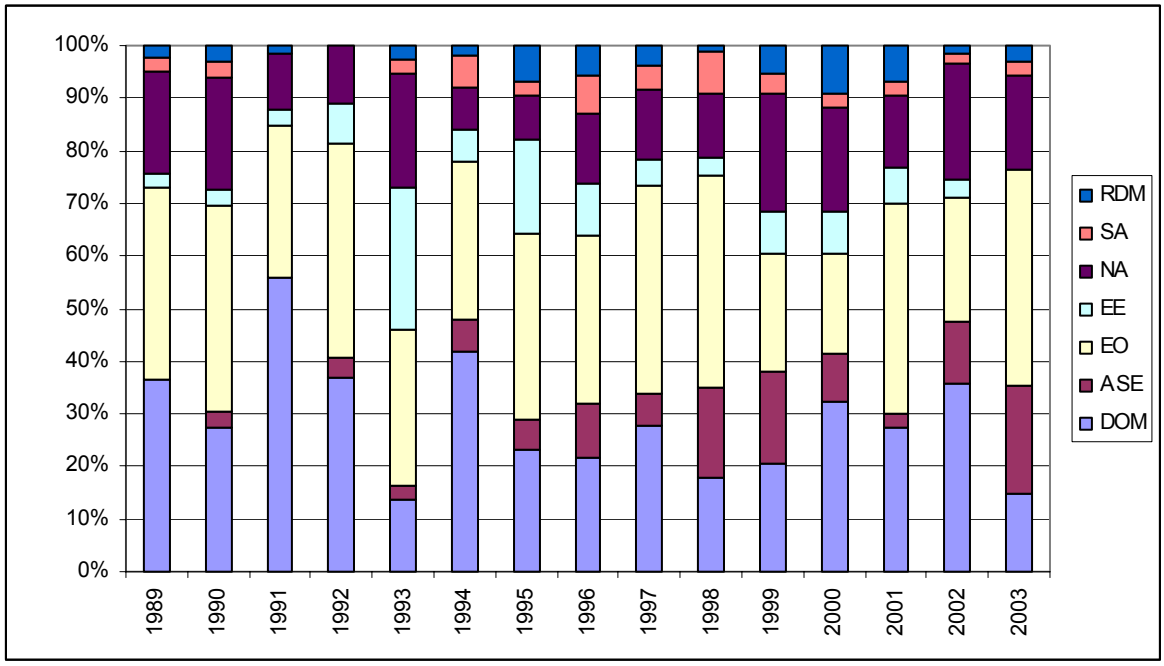
The first logic is "follow sourcing", wherein FTS accompany their traditional prime contractors when the latter try to embark upon their own internationalisation drives. This is the oldest logic, dating back to the aftermath of WWII for American suppliers, who at the time would often get their subsidiaries to imitate the Big-Three automakers' moves into Europe. The shift to modularity has brought back this logic, due to:

- The generalisation of platform politicise, with carmakers breaking their models down into different variants that can be offered elsewhere than in their home country. The supplier chosen to supply modules for a model is supposed to be able to make delivery to the carmaker's plants anywhere in the world.
- The fact that a modular approach's underlying principle introduces a greater opportunity for sharing modules amongst different models.

In country terms, these localisation choices are closely tied to decisions made by carmakers, whose strategies to set up operations in South America, Eastern Europe and more recently (at least for Westerners) in South Asia (*cf.* Lung, 2003; Carrillo *et al.*, 2004) have been directly reflected in suppliers' recent moves to expand overseas.

[7] Statistics have revealed global growth in the intra-branch trade of automotive equipment.

Figure 1. Number of Mergers & Acquisitions by geographic area (1989- July 2003) (%)



DOM: domestic; SA: South America; NA: North America; EE: Eastern Europe; EO: Western Europe; ASE: Asia; RDM: Rest of the World
Acquisitions made in a domestic zone are categorised as DOM. For example, a merger between two European firms is classified as a DOM. The same applies to operations between Japanese or North Americans firms. Inversely, the acquisition of a European or South American firm by an American FTS is classified, respectively, as EO or as SA.

Source: Authors' calculations based on Platinum (Thomson Financial) database

The second logic at work is customer portfolio diversification, wherein suppliers try to access new buyers. These attempts to build or acquire new facilities are a clear sign than FTS are seeking to set up operations in carmakers' own countries of origin. The behaviours they adopt vary from one firm or era to the next. To summarise global trends, we could say that in the 1980s and especially the early 1990s, American suppliers tried to reinforce their presence in Europe, and that Japanese suppliers did the same in the US and Europe. From the mid-1990s onwards, the Americans have tried to reinforce their presence in Asia; the Japanese have moved into Europe; and the Europeans have remained highly focused on the American market (although a few have clearly sought to gain a foothold in Asia).

The third logic derives from the international division of the production process. The cost (profitability) constraint that weighs upon suppliers encourages them to break their production process down into parts and to delocalise certain kinds of output. This explains the repeated efforts since the late 1970s by major American suppliers to set up plants in low-wage countries (with Mexico[8] constituting their main target zone, c.f., Lara Rivero and Carillo 2003 ; Carrilo, 2004). European suppliers make similar moves, albeit at a later date (first targeting North Africa and then Eastern Europe; *cf.* Brocard and Darmaillacq, 2006;

[8] Mexico is also used by European suppliers trying to move into the US, in much the same way as American suppliers' strategy is to use Eastern Europe as a springboard to penetrate the EU.

Domanski *et alii*, 2006). The same can be said about Japanese suppliers' move into south Asia (on these different zones, *cf.* Humphrey *et al.*, 2000; Humphrey, 2000).

The three logics sometimes combine in a given country/geographical zone. For example, a French supplier's operations in Eastern Europe might be based on[9]:

- Follow sourcing, i.e., accompanying PSA or Renault's opening of new foreign facilities;
- Diversification, i.e., capturing a new market with a foreign carmaker (like VW);
- Division of labour, where the supplier builds a plant to manufacture components that will subsequently be re-imported into the European Union.

This convergence of logics in one and the same country explains why it is so hard to interpret global (sectorial or national) statistics in terms of what such data might signify for a firm's spatio-organisational trajectories[10].

Since trajectory interpretation remains our objective, we need to clarify how vertical relationship transformations tie into production and development entities' localisation logic(s). Production process fragmentation can be linked to developments in modular production that have helped to accelerate international (de)localisations insofar as the search for upstream production savings, combined with greater autonomy in module components design, has made it easier to build production sites specialising in one or another range of components, which are then integrated into a module destined for one or several clients. IT provides a good example of this. Product architecture efforts have led to the emergence of many specialised suppliers seeking to establish operations in South Asia to benefit from weak production costs thanks to the disconnect between the development and production phases (Ernst, 2002; Sturgeon, 2003). Generalising this reasoning, we could say that modularity is crucial to a proper understanding of the dynamics driving spatio-organisational trajectories. However, since automobiles are a more complex activity than IT is, the best way to specify different proximity needs is to see them as a function of the particular activities in question.

4. Internationalisation guided by proximity dynamics in a modular context

4.1. The intensity of modularity-induced interactions

Most theorisations of modularity underscore that the advantage of this type of organisation resides in its simplification of the coordination function. This is mainly for cognitive reasons relating to interface standardisation and module interoperability, especially where modules are capable of adapting to successive product generations (Veloso and Fixson, 2001). Coordination is limited to the transmission of (codified) information, something that is easy to achieve using IT (Sanchez, 2000) without weakening modules' technological and

[9] The French Ministry of Industry's Statistics Department estimates that in early 2003 French suppliers owned 65 sites in Eastern Europe and employed a total of 20,000 persons. 26% of all new business locations chosen by German suppliers between 1997 and 2002 were in Eastern Europe (German Automotive Industry Association).

[10] Specifically, statistical tools do not make it any easier to identify delocalisation polemics. Some interpretations of the growing number of supplier (and carmaker) operations being built in Eastern Europe (Lung 2003) might intimate that a vast delocalisation movement is afoot, but in our opinion the phenomenon is more complex, since the international expansion drive with which it is so closely entwined has little to do with a substitution logic.

innovative contents. This is a direct result of incremental innovation possibilities derived from architecture and inter-supplier competitive dynamics (Baldwin and Clark, 2000).

This model may explain the structuring of industries like IT or electronics, but recent studies (Hobday *et al.*, 2005; Prencipe *et al.*, 2003; Brusoni and Prencipe, 2001) have shown that modularity transfers in technologically more complex sectors require something more complex. Automobiles are based on a system integration logic (Sako, 2003). By this, we mean that automotive branch actors need to work closely with one another to interlink their respective competencies (Lung, 2001). This is a sector where the "vanishing hand" principle may not suffice as a modus operandi for modularity (Langlois, 2003), which instead requires close cognitive and productive coordination between suppliers and carmakers (Frigant and Talbot, 2005).

However, we do feel that this stance should also be nuanced, seeing as modularity induces a deformation of the locations and objects of inter-firm coordination. *When one focuses on FTS and considers their buyer relationships, it appears that some of their activities function according to the tenets of a system integration logic, whereas others are partially exempt from this and more grounded in a vanishing hand logic*.

To argue this point, we would highlight the nature of the interactions linking a carmaker-buyer and a given FTS (whom we consider the focal point of our analysis). More specifically, we wonder whether such interactions will or will not intensify within a modular organisation. Two elements might help to answer this question:

Which critical interactions are being transformed through modularity? Using studies by Baldwin and Clark (2000), we will distinguish between two analytical levels relating to modularity's adoption: Modularity-in-Design; and Modularity-in-Production. Our idea is that cognitive and material interaction issues (i.e., knowledge and product flows) are crucial.

Given FTS' new status, which areas of activity are being rearranged within the overall value chain? In a dynamic perspective and as we have seen, some major changes have affected a range of FTS activities, raising questions as to which of these new responsibilities require closer coordination between a given FTS and a carmaker, and which are less directly linked to a specific carmaker. We can formulate this problem by asking whether a given FTS operates in an area of activity that is exclusive, or not, to a given carmaker[11].

4.1.1. The dualisation of design phase interactions

At a first level, more and more FTS research today is disconnected from the carmaking sphere. FTS have been trying to design the architectures of the modules they offer in a way that introduces new functionalities which will help them achieve an innovation monopoly. This explains why FTS have been reinforcing their upstream research capabilities, especially where the modules involved are multi-technology in nature, subject to intense competition and affected by regulatory and technological developments.

At the same time, since an automobile can, to a certain extent at least, be categorised as a Complex Products System (CoPS), the interlinkage of its various constituent modules

[11] The thinking is similar to Williamson's use of asset specificity (1985), although it differs insofar as we do not reason within a contractual framework.

implies a reinforcement of interactions at the modular level. In other words, a modular-supplier should reinforce interactions both with the specific carmaker with whom it is working on a given vehicle module, and also with any other supplier that has responsibility for a complementary and/or physically interconnected module. Despite the interface standardisation efforts that have been made, the automobile remains a product system whose interfaces are difficult to specify *ex ante*. It is hard to break automobiles down into modules - previous solutions are rarely reproduced at the modular level because of the integrity constraints that weigh upon the product-system (Clark and Fujimoto, 1991). This means that the cognitive interactions between a supplier and a carmaker's engineering teams are just as important as they ever were, and probably more so. After all, modular architecture signifies greater inter-firm coordination needs at a product's most upstream stages, due to the fact that module specifications are frozen very early on, and because any errors will be very costly.

Moreover, the specific nature of carmakers' chosen architectures (Batchelor, 2006; Gadde and Jelbo, 2002; Chanaron, 2001) has stoked a rise in the number of teams dedicated to each carmaker, and even to each of a given carmaker's projects. Rising confidentiality problems have accentuated this phenomenon: due to the fact that each module is a key element in product differentiation; and because FTS sometimes have access to information about an overall architecture, and even about other modules.

On the other hand, once the module's architecture is validated and the compatibility of interactions between its internal and external components verified, it becomes easer to isolate which design work affects the components themselves. Without falling into the sort of schema that has been identified in the IT sector, where the final assembler does not need to be aware of a module's contents (in a case of invisible components, as opposed to visible ones that the assembler alone needs to be familiar with, c.f., Baldwin and Clark, 2000), supplier-customer coordination constraints are less stringent for the inside of a module.

However, the splintering of FTS research teams provides justification for rationalising shared and transversal research resources, and for compiling internal data bases (like *Product Data Management*). The purpose here is to avoid duplication costs. What is revealed is a need to reinforce intra-firm organisational integration mechanisms.

We therefore hypothesise that R&D activities are broken down into two units:

1) RD^m: a R&D activity relating to the architecture of the module actually on offer, and to its constituent components. This R&D activity is disconnected from carmakers activities. The FTS aim to concentrate RD^m in a way that cuts costs by encouraging economies of scale and scope and by facilitating the emergence of learning effects.

2) RD^i: an activity involving the module's integration into the global and specific architecture of each carmaker, and which therefore implies intensive cognitive interactions. This RD^i is accompanied by a duplication of dedicated teams.

4.1.2. The dualisation of interactions during production phases

The same sort of duality can be found at the material production level by borrowing from the properties of (pure) modularity and integration. A FTS manages two distinctive types of production: the module, construed as a complex (sub)assembly; and the components of the module it is trying to standardise and commonalise amongst several modules. In virtue of the principles of modularity, components production may be largely disconnected from the

carmaking sphere, to the point that they sometimes embody an end user's role. In this case, components production and development becomes the responsibility of the FTS, who also reproduce pyramid sourcing upstream, increasingly seeking to externalise these very same production and development functions. FTS aim here to expand the market for these components. Depending on the vertical integration schema being applied, they will act internally or externally to increase the commonalisation rate of the components they have integrated into the different modules they are selling to the different carmakers.

Although there is less of a need for a dyadic relationship between carmaker and FTS when a module's constituent components are at stake, problems with module per se can be quite complex. The integration of modules onto carmaker assembly lines becomes a crucial factor, especially where this line functions according to a just-in-time (in actual fact, a just-in-sequence) mass production principles and is subject to extreme transportation volume constraints. In addition, the shift to modular production is often accompanied by the purchasing of a broader scope of contents, as per the tenets of a bundling logic that intensifies the services associated with a product's material delivery (Salerno, 2001). Lastly, the in-factory implementation of such principles requires a form of inter-organisational learning that exacerbates firms' staff coordination needs.

We can therefore hypothesise that at the production level it is possible to distinguish:

1) P^c: the production of components used to manufacture modules destined for several carmakers (or at least, this is the FTS' ostensible aim). This production tends to occur on sites that have been specialised in such a way as to generate economies of scale and scope whilst encouraging learning effects.

2) P^m: the production of carmaker-specific modules whose integration creates an intense need for interactions to facilitate the modules' insertion into the carmaker's assembly line flows. Site duplication becomes a necessity in this instance.

4.2. Forms of proximity and internationalisation schema

The grid above, based on the dual criterion of the degree of a buyer relationship's exclusivity, on one hand, and the nature of the activity in a modular production framework, on the other, allows us to explain suppliers' internationalisation schema.

Table 4. Summary of proposals

Activity	Geographical proximity to a given carmaker	Internationali-sation	Country/zones	Observations
R^i	Strong	Strong Site duplication	All countries; Following localisations of carmakers' design centres	If there is a previous history between the FTS/carmaker: possibilities for remote coordination thanks to proximity and ICT. Modular logic leads to a concentration of R&D in central countries
R^m	Weak	Little Concentration	FTS country of origin Potentially involves countries with specific competencies and even major markets	Probable rationalisation in large R&D centres
P^m: final assembly of modules	Strong	Strong Site duplication	All countries; Following carmakers' production facilities	Carmakers' internationalisation encourages a proliferation of sites (emerging countries)
$P^{m:}$ production of modules (complete, sub-assembly)	Strong	Trade off: site duplication *vs*. concentration (eco. of scale)	H1: All countries, following carmakers H2: Barycentre logic: central countries or even emerging countries where there are many geographically concentrated carmakers	
P^c	Weak	Potentially strong	Countries on the periphery of the main automobile-producing zones Search for comparative advantage	FTS should develop a strong organisation to manage its different entities and/or integrate second tier suppliers

4.2.1. The location of design and development activities

At a surface level, module finalisation accentuates the need for buyer-supplier coordination (RD^i). The need to control inter-module interactions, as well as the interactions between modules and the whole of the product-system that is the completed car, creates in turn a need for greater coordination amongst the different FTS chosen for the project, and amongst the FTS and carmakers. Playing an integrator's role, the carmaker pilots the entire FTS network, starting with the future model's initial design phases. This attests to the relevancy of the 1990s vintage management tools that are being used towards this end (project team, concurrent engineering etc.). It remains that face-to-face interactions continue to be an essential tool in R&D organisation, even if digital mock-ups and PDM have made it easier to create dual organisations allowing for a coexistence of research team decentralisation and centralisation. At the same time and as we have seen, an increasing proportion of FTS research is not linked to any specific carmaker (RD^m). "Basic" (i.e., non-dedicated) research is on the rise, with some such activities having been taken out of carmakers' remit and lodged in research centres that do not pursue any geographical proximity objectives. At the same time, FTS must ensure that development centres built in their buyers' vicinity can be coordinated with central FTS research offices, so that they can be converted into resource centres that are capable of sustaining whatever dedicated carmaker-specific developments are required.

From an internationalisation perspective, this logic tends to legitimise a twofold R&D activity localisation strategy. Firstly, FTS find it hard not to build their development centres in those countries where carmakers have situated their design activities. Geographical proximity is all the more crucial when a new client is being prospected (as per a portfolio diversification logic) since the FTS has no past experience to rely upon. Here there is no such thing as prior inter-organisational learning, meaning that it is impossible (or very difficult) to use ICT as a means of remote coordination. Our empirical results confirm that FTS have generally built a greater number of development centres in countries where carmakers run operations.

One apparently paradoxical element in this movement is the fact that certain design activities that FTS used to carry out in emerging automobile countries like Brazil or India now tend to be repatriated to central countries (North America, Europe, Japan). The explanation lies in the shift to the modularity/platform tandem. Platforms enable today's carmakers to use their central design studios to undertake most of the local adaptations of the cars that they will be selling in emerging countries. This means that where platform-manufactured modules are involved, FTS are concentrating their development activities in central countries (Humphrey and Salerno, 2000; Humphrey, 2000).

As such, development activities do contribute to the emergence of a twofold crossed movement. A given FTS will tend to disperse its design centres abroad to improve its ability to survey and interpret the demands of those carmakers it is targeting. The less familiar a FTS is with a given carmaker (and vice versa), the better it is for the two organisations to work in each other's geographical vicinity. At the same time, FTS have also been reinforcing their national R&D capabilities since they are already running operations in the central zones where their traditional buyers' R&D centres are located[12]. After all, module finalisation requires close forms of geographical proximity, if only temporarily. This legitimises the duplication of teams, including domestically.

Questions are raised at this level as to the localisation of more upstream research activities (RD^m). Our observations seem to confirm that FTS are inclined to reorganise themselves into centralised research centres. For instance, this is what the French firm Faurecia stated in its presentations of the opposition between development and design centres (19 globally, 3 in the US and 16 in Europe, including 8 in France in 2002) and R&D centres (8 including 5 in France and 3 in Germany) (See Appendix). Geographical proximity to a given buyer no longer seems necessary – although FTS do need to closely interlink the dedicated development teams it sends out to work alongside each of its carmaker customers. A close integration of these different FTS teams is a tool allowing suppliers to manage whatever physical distance exists between their various units. In a modularity logic, what we should expect are rationalisation efforts aimed at reinforcing research centre facilities located in FTS' countries of origin, occasionally supplementing them with new facilities situated in countries characterised by a sufficiently large market (portfolio diversification) and/or featuring complementary competencies that are sufficiently attractive to justify a duplication of centres.

[12] The major global suppliers originate from the large automobile-producing countries, with the exception of Magna, a Canadian firm. In terms of the world's Top 100 as measured by 2002 revenues, we also find this coupling of carmakers' and FTS' nationalities – except for Rieter (Switzerland) and Antolin (Spain, a country that despite lacking a national car manufacturer remains a major production centre).

Furthermore and in some still infrequent instances, concentrating module components production in peripheral countries (see below) can trigger the founding of a RD^m centre in a country where a FTS possesses a strong productive base. This is why Delphi turned Ciudad Juarez into a major cable activity development centre. The shift to modularity induced the group to launch this RD^m in 1995 so it could benefit from the proximity effects amongst its many locally clustered entities (Lara Rivero, 2002; Lara Rivero and Carrillo, 2003 ; Carrillo, 2004).

4.2.2. The location of production activities

For production activities, we can distinguish between two types of facilities: those requiring an increased need for geographical proximity, thus warranting the reinforcement of central country entities (or inversely, international expansion); and those marked by a lesser need for buyer coordination and which therefore allow for a dispersion of activities.

This latter case mainly pertains to components that are meant to be integrated into modules (P^c). In a modular logic, this type of production is disconnected from any one specific buyer. The production/development of such components is based on coordination undertaken by the FTS itself, who, by relying on its organisational competencies, is able to manage the production sites' geographical remoteness. These are activities that can be delocalised to low-cost production spaces. However, the choice of a host country is not entirely free. Indeed, downstream (module) delivery constraints imply a lean supply chain. This is because FTS tend to highlight facilities located in countries contiguous to the ones where they are undertaking the modules' integration. This phenomenon has been recently observed with second tier suppliers, with the FTS requesting increasingly explicitly that their own suppliers build, in countries of the FTS' choosing, (occasionally dedicated) components supply facilities. Here we have a follow sourcing logic that has shifted from a carmaker/first tier supplier tandem to a first tier supplier/second tier supplier one.

FTS' follow sourcing logic is closely tied to module production-related productive constraints (P^m). In a lean production context, modules' integration onto carmakers' assembly line requires close forms of geographical proximity. Inter-firm geography has therefore tended to develop in the shape of supplier parks (Larsson, 2002; Sako, 2005). The search for geographical proximity can be justified at three levels: by transportation flow volume constraints; by organisational learning needs encountered during the production process; and by the mutual commitment effects stemming from a site's specificity (Frigant and Lung, 2002). In our questioning of internationalisation, this seems to have given firms good cause to:

- Build more foreign entities in customers' vicinity (either when an existing carmaker customer moves into a new territory [follow sourcing] or when supplying a new customer [customer portfolio diversification]);
- Increase the number of domestic entities, for the same reasons, as carmakers set up new operations and as new markets are captured.

This proliferation of sites has run into a profitability constraint, however. It would be impossible for a FTS to build a production entity to make each module for each of its buyers. After all, many supplier parks resemble the adjoining of screwdriver workshops more than they do the building of a real production site (Larsson, 2002). The nature of these decentralised activities depends on the size that allows a site to break even. Since certain modules (like seats) are costly to transport, produced in synchronous flows and offer good opportunities for economies of scale, they are located on dedicated sites in the immediate

vicinity of a carmaker's plant. Inversely, modules that are less capable of satisfying these minimal conditions (i.e., cockpit modules) translate into facilities built near final assembly workshops, with production activities per se being carried out by other, more distant entities.

The notion of distance depends in turn on the structure of the market in question. The FTS generally tries to establish production sites in spaces located at what is the barycentre for several of its (current or potential) clients.

In internationalisation terms, this induces FTS to set up module production entities in countries featuring a sufficiently large reserve of potential customers. In this context, and given the uncertainty of such markets, FTS end up playing a localisation inertia card. Central countries (i.e., the country of origin) continue to be emphasized. Peripheral countries (like South America) are supplied with sub-assemblies that they import. The final assembly takes place in supplier park workshops. Occasionally, in this type of country, more complete entities will be built when several carmakers move into neighbouring regions and if sufficiently large production volumes are predicted. Note that carmaker proximity is a necessity here, due to frequent problems in managing just-in-time deliveries in countries characterised by a deficient transportation infrastructure.

5. Conclusion

First tier suppliers are good examples of the new types of firms that have been rapidly internationalising their production sites and organising a disintegrated production process. In recent years, companies of this sort have increased the number of entities they run abroad, and continue to do so. By so doing, they contribute to the rising global trade of intermediary goods. However, as we have seen, not all such entities are driven by a simple and single-minded search for the division of labour, with some pursuing traditional logics like proximity to one's newer or older customers.

We feel that there are two reasons why the acceleration of this internationalisation movement is connected to the development of modular production. Firstly, by reinforcing these actors' weight in the value chain, modularity has given them reason to try to expand their operations, including internationally. Secondly, modularity modifies inter-firm coordination practices. Proximity is no longer needed for certain activities and an international division of labour is now possible thanks to modularity. In this sense, we have returned to some of the conclusions that pundits had drawn from their analyses of the geography of modularity in the electronics and IT industries. Our conclusions converge with two of the findings from these other studies.

- On one hand, modularity allows for a decoupling of certain activities. The proximity constraint is loosened, enabling internationalisation for cost reduction reasons.
- On the other, certain activities still require close proximity relationships.

Nevertheless, since the present study covers an industry categorised as a CoPS, we should also take a nuanced view of our findings. Whereas delocalisation seems generalised in the electronics industry, with perennial clusters being more the exception than the rule, what we observe in the automobile business is that the cluster configuration that was so paradigmatic in this sector's development remains highly topical. Be it for development or final assembly purposes, close forms of proximity are still needed - even where this means building new clusters in those new countries where carmakers are setting up their new operations. For this reason, internationalisation and the search for proximity seem to be complementary and not contradictory phenomena. In parallel, we note the existence of factors

that, as is the case in the IT or electronics sectors, encourage "pure" delocalisation movements. Our objective has been to offer an analytical grid which could explain these simultaneous movements.

By reasoning in terms of the type of activities that FTS undertake and by focusing on the degree of exclusivity characterising a given buyer-FTS relationship, we have shown that a multitude of tandems can exist. In reality, what our analysis offers is reasoning based on a distinction being made between modules' contents and the modules themselves. When combined with thinking about the possibility of a FTS entertaining a dyadic relationship with a carmaker, this distinction, which underlines the diverse nature of the activities in question, helps us to understand FTS' different entity localisation choices. These analytical conclusions help to explain the simultaneous coexistence of several FTS localisation strategies, and also, alongside these actors' internationalisation drives, why they have been trying to reinforce their activities in their countries of origin or in the developed automobile-producing countries.

In this sense, the present study belongs to a research corpus which stresses that there is nothing inevitable about developed countries' deindustrialisation (Berger, 2005) – as long as carmakers maintain their main production and development sites in such countries.

We do feel, however, that our study should be expanded to see whether the typology it offers would be robust in other sectors. In particular, it would be interesting to extend the analysis to the aeronautics industry that, as a CoPS, presents similarities with the automobile sector from an organisational perspective (Frigant and Talbot, 2005). Over the past few years, and particularly for the launch of the Airbus A380 and the Boeing 787, we have witnessed the early seeds of aeronautics FTS setting off on internationalisation drives equivalent to the ones observed in the automobile sector, including through the establishment of new operations located in buyers' vicinity (in Toulouse [France] for Airbus, in Seattle [USA] for Boeing) and through the development of certain activities in low-cost countries lying on the central countries' periphery (Mexico, North Africa). Are these moves analytically in sync with the schema we have suggested for the automobile sector? Are they different in nature? And if so, what are these differences?

Appendix: Two French examples of international productive organisation

The case of Valeo: Employees and number of locations

Geographic Area	Countries	Employees	Production plants	R&D centres	Distribution centres
December 2002					
North America	USA, Mexico	*9600*	*17*	*11*	*0*
South America	Argentina, Brazil	*2700*	*12*	*0*	*1*
Asia	China, South Korea, India, Japan	*3600*	*16*	*4*	*0*
Africa	South Africa, Morocco, Tunisia	*7700*	*11*	*0*	*0*
Eastern Europe	Czech Rep., Hungary, Poland, Romania, Turkey (exit Slovenia)	*4800*	*11*	*0*	*2*
Western Europe	Germany, Belgium, Spain, France, UK, Italy, Netherlands, Portugal, Sweden	*40700*	*73*	*39*	*6*
Total	*25*	*69100*	*140*	*54*	*9*
December 2001					
North America	USA, Mexico	*10800*	*20*	*11*	*1*
South America	Argentina, Brazil	*2300*	*13*	*0*	*1*
Asia	China, South Korea, India, Japan	*3400*	*14*	*4*	*0*
Africa	South Africa, Morocco, Tunisia	*7200*	*9*	*0*	*0*
Eastern Europe	Czech Rep., Hungary, Poland, Slovenia, Turkey				
Western Europe	Germany, Belgium, Spain, France, UK, Italy, Netherlands, Portugal, Sweden	*46300*	*87*	*38*	*8*
Total	*25*	*70000*	*143*	*53*	*10*
December 2000					
North America	USA, Mexico	*11500*	*21*	*10*	*1*
South America	Argentina, Brazil	*2400*	*15*	*0*	*1*
Asia	China, South Korea, India, Japan	*3400*	*14*	*3*	*0*
Africa	South Africa, Morocco, Tunisia	*6580*	*11*	*0*	*0*
Eastern Europe	Czech Rep., Hungary, Slovenia, Turkey				
Western Europe	Germany, Belgium, Spain, France, UK, Italy, Netherlands, Portugal, Sweden	*51320*	*106*	*36*	*8*
Total	*24*	*75200*	*167*	*49*	*10*

Source: Valeo, Annual Report and Internet Website

The case of Faurecia: Numbers of location by geographic area

Geographic area	2002					1999				1998		
	Production	Design & development	R&D centre	Support client	Head - office	Production	Research centres	Support client	JV & licence	Production	Research centre	Support client
North America	**13**	**3**	**0**	**1**	**2**	**6**	**0**	**2**	**1**	**6**	**0**	**2**
USA	8	3	0	1	1							
Canada	4	0	0	0	1							
Mexico	1	0	0	0	0					abs	abs	abs
South America	**14**	**0**	**0**	**5**	**1**	**7**	**0**	**0**	**4**	**6**	**0**	**0**
Argentina	4	0	0	2	0							
Brazil	10	0	0	3	1							
Asia-Pacific	**8**	**0**	**0**	**6**	**0**	**3**	**0**	**2**	**5**			
Japan	0	0	0	4	0							
China	5	0	0	2								
South Korea	2	0	0	0	0					abs	abs	abs
India	1	0	0	0	0							
Africa	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**
South Africa	5	0	0	0	0					abs	abs	abs
Tunisia	1	0	0	0	0					abs	abs	abs
Europe	**119**	**16**	**8**	**25**	**3**	**63**	**4**	**21**	**0**	**64**	**5**	**18**
France	***37***	***8***	***5***	***2***		***26***	***3***	***9***	***0***			
Czech Rep.	4	0	0	0	0	4	0	0	0			
Turkey	4	0	0	1	0	2	0	0	0			
Slovenia	1	0	0	0	0	1	0	0	0			
Slovakia	2	0	0	0	0	abs	abs	abs	abs	abs	abs	abs
Poland	4	0	0	0	0	1	0	0	0			
Germany	23	6	3	14	3	12	1	8	0			
Sweden	1	1	0	2	0	1	0	2	0			
Luxem-bourg	1	0	0	0	0	abs	abs	abs	abs	abs	abs	abs
Nether-lands	2	0	0	0	0	abs	abs	abs	abs	abs	abs	abs
UK	6	0	0	4	0	4	0	1	0			
Belgium	3	0	0	0	0	abs	abs	abs	abs	abs	abs	abs
Italy	1	0	0	0	0	1	0	0	0	abs	abs	abs
Portugal	6	0	0	0	0	2	0	0	0			
Spain	24	1	0	2	0	9	0	1	0			
Total	**160**	**19**	**8**	**37**	**6**	**79**	**4**	**25**	**16**	**76**	**5**	**20**

Notes: abs= Country without location in the item; Blank: non available

Source: Annual Report Faurecia and Ecia (for 1998) and Internet Website Faurecia

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