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Egyptian pyramid or Aztec pyramid: How should we describe the industrial architecture of automotive supply chains in Europe?

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Pyramide égyptienne ou pyramide aztèque : quelle métaphore pour décrire l'architecture industrielle de la chaîne d'approvisionnement de l'automobile européenne ?

Résumé

Cet article s'interroge sur la description couramment mobilisée de l'architecture industrielle de la chaîne d'approvisionnement automobile. Depuis le mouvement de désintégration verticale des années 1980s, cette architecture est représentée à travers l'image d'une pyramide. Implicitement, les auteurs ont en tête une pyramide égyptienne, très pointue à son sommet, très large à sa base. Nous montrerons que, si pyramide il y a, elle est plutôt de type aztèque : avec un sommet tronqué et laissant une place aux PME. Dans une première partie historique, nous expliquons les éléments qui ont conduit à l'architecture pyramidale. Dans la deuxième partie, nous soutenons que la métaphore égyptienne est plus trompeuse qu'éclairante. Dans un premier temps, nous soulignons que la mobilisation excessive de cette métaphore finit par exclure de l'analyse des entreprises stratégiques. Ensuite, nous présentons les résultats d'une étude réalisée auprès de 750 PME françaises montrant que certaines PME accèdent encore directement aux constructeurs et que la hiérarchie des rangs est plus poreuse que ce qu'on pense.*

Mots-clés : modularité, architecture industrielle, automobile, chaîne de valeur, PME.

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Abstract

This article questions a terminology that is frequently used to describe automotive supply chains' industrial architecture. Since vertical disintegration became a trend in the 1980s, this architecture has been represented using the image of the pyramid. Implicitly, authors have had the image of an Egyptian pyramid in mind, one that is pointed at the top and broad at the base. We will demonstrate that even if pyramids are an appropriate image, in the auto industry the Aztec variant, with its shortened peak and room for SMEs, is more accurate. The paper's first section – with its more historical focus – explains the birth of the Egyptian pyramid. The section 2 puts forward the idea that the Egyptian metaphor is more misleading than informative. We start by demonstrating that overusing this metaphor will ultimately exclude a number of very strategic companies from analysis. This is followed by a presentation of the findings from a study of 750 French SMEs, in which it is demonstrated both that some continue to maintain direct access to carmakers and also that the hierarchy of tiers comprising this supply chain features greater porosity than is commonly recognized.*

Keywords: modularity, supply chain, industrial architecture, SME, automobile.

JEL: L23, L24, L62, O33

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> *"The supply base of today's carmakers is structured like a pyramid. On top of the pyramid is the carmaker. Below the carmakers are a small number of Tier 1 suppliers that sell parts directly to carmakers. Tier 1 suppliers in turn purchase materials from Tier 2 suppliers, who purchase from Tier 3 suppliers, and so on down the supply chain."*
>
> *(Klier, Rubenstein, 2008, p. 109)*

Introduction

For the past 30 years, automakers have relied increasingly on outsourcing, with most observers agreeing that this has been accompanied by a strong trend towards vertical disintegration. At the same time, there is no real consensus regarding the industrial architecture associated with this organisation - a term referring in the present instance to the general architecture of the supply chains in question, hence to the structural composition of the firms that intervene in said supply chains (their size, productive specialisation, scope of activities, number and location of productive units, etc.) and to the interlinkages between different subcontractor levels[2].

In the early 2000s, the outsourcing trend lent itself to two different interpretations. The first derived from a modular hypothesis (Fine, 1998; Sturgeon, Florida, 2001; Sturgeon, 2002: McAlinden et al, 1999; Veloso, Kumar, 2002) and was comprised of studies asserting that modularity-related developments would lead to a significant pyramidisation of supply chains, with several world-class suppliers capturing the lion's share of the OEM markets that supply carmakers directly, a tier that is almost exclusively comprised of complex modules and subassemblies. Indeed, many empirical studies have demonstrated that disintegration following a "cascade effect" (Nolan, Zhang, Liu, 2008) has culminated in a restructuring of supply chain architectures, as witnessed by the emergence of mega-suppliers (Frigant, 2009; Klier, Rubenstein, 2008). Opposing this thesis, G. Herrigel (2004) has stated that

> *"There are also a very large number of problems with the image of a completely modular automobile industry and hence obstacles to the emergence of the highly concentrated and vertically integrated component industry outlined by Sturgeon, Florida and others (…) it is possible to think that there continues to be a very robust space for independent small and medium-sized component production in these industries" (p. 49).*

The present article returns to this debate and in its bid to establish a new inventory of automotive supply chain architectures. This effort is justified for two reasons.

- Firstly, T. Sturgeon and R. Florida (2001) explain that modularisation is a process. When they wrote their paper, we are at the very beginning of this process. And we can suppose that a lag effect does exist. Automobile supply chain will become a modular-chain. At the same time, G. Herrigel has contested this point with the argument that the heterogeneity process is fundamentally destined to last. In this vision, in addition to module suppliers carmakers still need other suppliers, including small and medium-sized enterprises (SMEs). Examining current industrial architecture should help us to verify this hypothesis (delay vs. process renewal).
- The second reason ties to the conclusion of an article written by G. Herrigel (2004), which asserted that strong pressure on SME margins makes them particularly fragile in times of economic slowdown. T. Rutherford and J. Holmes (2008) have also highlighted the fragility of

[2]The architecture of a supply chain is comprised of two closely related aspects: the industrial architecture, referring to this structure of the companies in question (and to their interlinkages) and the organisational architecture, referring to their modes of coordination (market, hybrid forms, relational mode, etc.). The present article focuses on the former aspect even as it, quite understandably, recognizes that both are interdependent.

Canadian SMEs contending with mega-suppliers and carmakers' strategies. The question here is whether the crisis of 2008/2009 has evicted a number of SMEs from automotive supply chains or, at the very least, pushed them further down the supply pyramid.

This pyramid metaphor has more or less generalised as a way of describing automotive supply chains. It is a good starting point for our own thinking in this area. Implicitly, authors using this image are thinking about an Egyptian pyramid that is very pointy at the top and very broad at the base. This article, on the other hand, will demonstrate that even if the image of a pyramid is appropriate, surely it is the Aztec variant that is more useful - at least in the case of Europe – featuring a truncated peak and leaving room for SMEs. Indeed, the paper's second section will focus on Europe and replicate findings from an original investigation covering 750 SMEs in France that worked for the automotive industry in 2010. This survey will allow us to ascertain whether SMEs have been relegated to the automotive supply chain's second or third tiers while enabling discussion of issues relating to each tier's level of porosity.

Before this, however, the first section will adopt a historical perspective and highlight factors underpinning the pyramid architecture. The second section then shows in two ways that the Egyptian metaphor is more misleading than informative. The first point is that overuse of this metaphor answer excludes strategic actors from analysis. The second presents findings from a study of large sample of French SMEs and confirms the aforementioned analyses.

I. From flat hierarchy to Egyptian pyramid: the challenge for Western carmakers

During the fordist era, the dominant industrial architecture of the western carmakers was a flat hierarchy (Fujimoto, 1999). It was constructed around the following tripod: 1) strong vertical integration; 2) reliance on many suppliers and above all subcontractors who tended to be small in size; 3) with the latter dominated economically and technologically by carmakers who made wide use of multi-sourcing. On the contrary, the Japanese carmakers had already built a pyramidal architecture (Shimokawa, 1994, Cusumano, 1989) based on: 1) significant outsourcing; 2) reliance on a small number of direct suppliers engaged in mono-sourcing and producing complex elements (subassemblies); 3) a pyramid driven by a size logic and populated by large first tier suppliers with SMEs tending to operate on tiers 2 and 3.

The late 1980s and early 1990s saw widespread recognition of the originality of Japan's organisational model for vertical relationships. Womack, Jones and Roos's global bestseller *The Machine that Changed the World* (1990) contributed strongly to the model's popularity by highlighting its performance and helping, among others outcomes, to convince Western carmakers of the merits of changing their supply chains. American and European manufacturers would henceforth try permanently to imitate the Japanese model - with such imitation efforts ultimately culminating in a form of hybridation (Boyer et al, 1998). Of course, it was this stage that spawned the DNA driving future changes in vertical relationships.

1.1. Adopting the Japanese pyramid

Thus, Western carmakers began to appropriate the Japanese model and tried to adapt it. Terms such as kanban, kaizen, lean manufacturing and codesign started to circulate in carmakers' workshops and offices. Clearly, Western carmakers did not adopt absolutely everything and ended up taking an interest in different aspects of the paradigm with varying degrees of haste (Freyssenet et al, 1998; Boyer et al, 1998). In other words, each carmaker had its own way of appropriating the ingredients of a Japanese model that in any event does not really exist in a single form (Freyssenet et

al, 1998). All in all, there is no doubting the general interest in adopting different elements of the "model". Moreover, on at least one point there was a consensus – the need to alter current vertical relationships, notably the industrial architecture.

Carmakers committed to cut their vertical integration rates, something that would soon be viewed as involving the construction of a supplier hierarchy. The first step consisted of reducing the number of direct suppliers. Towards this end, the reliance on multisourcing began to be contested in people's rush to generate economies of scale by concentrating on a shortlist of chosen suppliers who would be asked to do more than they had previously. Building a pyramid assumes, after all, that components be reaggregated by means of subassembly purchases. Yet subassemblies require suppliers with a modicum of development capabilities, adding in turn to the fixed costs. Such capabilities are particularly attractive to carmakers when they involve outsourcing even more than the production function alone (i.e. the detailed design of subassemblies/components). The aim was to reduce the volume of fixed assets but above all to cut new car projects' time-to-market at a time when Western carmakers were not doing nearly as well as their Japanese counterparts (Clark, Fujimoto, 1991; Womack, Jone, Roos, 1990). The end result was a rapid decline in direct suppliers between 1986 and 1996 (Table 1).

Table 1 – Number of direct suppliers to selected American and European carmakers (1986-2000)

	1986	1996	2000
PSA	1,229	600	500
BMW	1400	900	600
Ford	2,400	1,200	1,200
Chrysler	3,000	1,000	600
Renault	1,400	540 (1997)	n.a.
Fiat	1,200 (1987)	380 (1995)	330 (2001)

Sources: Whitford, Enrietti, 2005; Veloso, Kumar, 2002; Enterprise

This design outsourcing phase (or at least, a phase marked by greater sharing between suppliers and carmakers) can be measured by breaking components down by their designer. Returning to a distinction introduced by K. Clark and T. Fujimito, Table 2 shows that from one decade to another, carmakers were increasingly asking their suppliers to develop and design the elements (parts) that they needed. It remains that Western suppliers' very limited initial capabilities meant that the carmakers themselves had to get involved.

Table 2 – Who design the parts?

	Japan		US		Europe	
	1980s	1990s	1980s	1990s	1980s	1990s
% of black box parts	62	55	16	30	29	24
% of detail control parts	30	39	81	58	65	64
% of suppliers' proprietory parts	8	6	3	12	6	12
Total	100	100	100	100	100	100

Source: Fujimoto, 1999, p.201

As a result, the Fordist era ended up in the supplier fabric atrophying. Yet a pyramid architecture assumes that tier 1 suppliers are capable of fulfilling their status. This meant that before long, most carmakers started encouraging the emergence of a useful supplier fabric.

In Europe, this involved choosing a small number of "high potential" companies whose development should be supported (Laigle, 1995). Quality certifications became a privileged tool for assessing suppliers' organisational ability to achieve first tier status (Gorgeu, Matthieu, 1995). By so doing, carmakers were sowing the seeds for future mega-suppliers. In certain cases, this gestation

activity involved their prioritising their own equipment-making subsidiaries (whose important role is discussed below). At the same time (and as noted by M. Sako and S. Helper in 1999), the late 1990 witnessed certain equipment making suppliers behaving in a very proactive manner and autonomously defining their own development strategies. Lamming (1993) has come up with long details of suppliers' emergence strategies, identifying four different categories: 1) leader key players with a strong automobile specialisation and whose objective was to become first tier suppliers with major automobile-specific R&D activities 2) follower key players comprised of large companies for whom the automobile was one product in a broader portfolio; 3) loyal collaborator leaders who would develop production and innovation capabilities working closely together with their main carmaker; and 4) loyal collaborator followers who seemed destined to slip to the bottom of the pyramid. The strategies may have differed but the consequence was always to divide suppliers' roles between those who were destined to occupy the carmaker's first tier versus others whose destiny was to be relegated to the second or even third tier.

This architectural restructuring happened very quickly, especially since it coincided with a new internationalisation phase for both carmakers and suppliers. For the former, productive internationalisation led to an increased number of production sites manufacturing identical models (and above all, to models being built using identical platforms). Indeed, one major issue in the late 1990s consisted of reducing the number of platforms used to produce an ever greater number of models (Lung et al, 1999). In this view, carmakers were expecting suppliers to achieve economies of scale and follow them abroad. The end effect was that suppliers became increasingly selective in terms of their own ability to supply different factories producing the same vehicles - leading in turn to a certain tightening at the top of the pyramid. Alongside of this, suppliers forced to follow their traditional customers abroad suffered from higher fixed costs. To restore margins, they would try to capture new local customers, leading in turn during the 1990s to a real race to internationalise by the different suppliers in this category, paving the way for a pyramid structure. Indeed, the arrival of new foreign suppliers on the scene allowed the break-up of the monopolistic forms that were taking shape at a domestic level in the pyramid logic, thereby facilitating its implementation on the part of carmakers who continued to worry about the risks of having to face monopolies[3].

One special trajectory for suppliers would involve external growth since this enables simultaneous responses to the twofold challenge of internationalisation and the extension of competencies (technological ones but also organisational competencies since the pyramid logic force suppliers to manage their own supply chains). In a 2003 study of 30 of the world's leading suppliers, we estimated that this population engaged in 957 merger and acquisition operations between 1989 and July 2003 (Table 3). Most of these operations occurred in the developed world and were intended to achieve the dual aim of penetrating new markets and enhancing companies' knowledge base. In reality, the 1990s were a decade when the mega-suppliers that would become so central to the ensuing modular revolution first began to make themselves known.

At a more contractual level, the quasi-rent relational paradigm (Asanuma, 1989) would increasingly become part of the general narrative, with people no longer talking about subcontracting but instead about partnerships (Lamming, 1993). Clearly, this model – promoting an overall coherency - took a long time to establish and halfway through the 1990s a clear distinction existed between American and Japanese carmakers (Sako, Helper, 1995) and even their European counterparts (Sako, Helper, 1999).

The road seems, however, to have been clearly laid out: 1) product complexification; 2) bigger suppliers due to dual effect of internationalisation and greater R&D capabilities (which started to

[3] This derives notably from the history of Western carmakers who are accustomed to dominating their vertical relationships and have little experience of the partnership approaches that they ostensibly supported.

become autonomous insofar as they were no longer specifically attached to a single carmaker); and 3) the rise of increasingly complex (but not necessarily fair) contracts[4].

Table 3- Mergers and Acquisitions by 30 leading suppliers (1989-July 2003)

Areas / *Sector*	Western Europe	Eastern Europe	North America	South America	Asia	Rest of world	Total
Transportation Equipment	93	15	50	17	40	12	227
Electronic and Electrical Equipment	51	14	24	6	11	2	108
Business Services	41	7	20	4	2	2	76
Metal and Metal Products	40	9	21	2	1	3	76
Machinery	41	4	8	1	10	2	66
Communications Equipment	31	4	12	0	1	1	49
Wholesale Trade-Durable Goods	26	1	9	3	8	2	49
Rubber and Miscellaneous Plastic Products	13	6	5	1	10	4	39
Measuring, Medical, Photo Equipment; Clocks	14	1	16	0	1	2	34
Prepackaged Software	17	0	8	0	2	1	28
Telecommunications	15	2	5	1	0	2	25
Textile and Apparel Products	12	2	6	0	1	1	22
Chemicals and Allied Products	7	1	5	0	2	0	15
Computer and Office Equipment	8	1	6	0	0	0	15
Construction Firms	5	0	5	0	2	0	12
Real Estate; Mortgage Bankers and Brokers	12	0	0	0	0	0	12
Aerospace and Aircraft	7	0	4	0	0	0	11
Wood Products, Furniture, and Fixtures	3	0	5	0	2	0	10
Others (total 21 sectors)	42	5	25	1	1	3	77
	478	72	234	36	94	37	951

Note: Two operations could not be classified on a sectorial basis and only four could be classified along geographic lines.
Source: Platinium, Author

With hindsight, it seems to us that the extension of outsourcing - despite the margin for progression that still remained - was destined to run out of steam. It is thus that we interpret the success of the modularity theme.

1.2. The modular era

In the late 1990s/early 2000s – a time when suppliers and carmakers would often be found working alongside one another - modularity became a permanent focus that would sometimes even become a fantasy for these parties. Carmakers hoped that they could use this as a solution for their recurring problem with fixed costs and customer diversification. Modularity would enable a reduction in the number of platforms while allowing carmakers to maintain and even increase the number of different versions that they could offer customers (Gawer, Cusunamo, 2002). It would open the door to mass cutomisation while reducing the time required for design and production and paving the way for a new outsourcing phase (Sako, 2003; McAlinden, Smith, Swiecki, 1999). As for suppliers, the ones who had been most committed to the earlier consolidation trend saw this as an opportunity for passing a threshold and consolidating their position as major players. Moreover, it was in Europe, where supply consolidation had made the most progress, that the modularity temptation received the greatest priority (Sako, Warburton, 1999).

[4] Flynn (1998) provides good information on the gaps between narratives about partnerships and real practices for carmakers like GM. A decade later, these practices still seemed inconsistent (Senter, McManus, 2009).

At the turn-of-the-century, forecasters were predicting very strong growth in the modules market for the ten years to come, expecting average values to rise from USD794 per vehicle in 2000 and the contents of supplier-delivered modules to rise to USD1,764 by 2010 - a 166% jump in the global market for modules (Table 4).

Table 4 –Growth forecasts in the market for outsourced modules in 2000

in USD 000s	2000	2010	Index base 100 in 2000
Total modules	41,682	111,050	266
Inc.			
Internal modules	16,974	45,960	271
Chassis and external	5,206	20,312	390
Driving system	19,504	44,781	230
Average value per vehicle (units)	*794*	*1,763*	*222*

Source: AutoBusiness-SSB, 2004

Futurologists began to see the automobile as a puzzle comprised of different modules (the number 50 was sometime mentioned) produced by a few suppliers delivering to all of the factories worldwide whose assembly operations involved the use of shared platforms. More modestly, the idea began to make its way that modularity was destined to thoroughly restructure the ambient industrial architecture by means of a highly pyramidal form of organisation featuring a few mega-suppliers delivering complex modules and systems - with any leftover subcontracting (split among the remaining suppliers) becoming very marginal. In parallel to this, mega-suppliers were supposed to head subcontracting networks, consolidating an already highly structured supply pyramid and causing its peak to narrow even further.

At a theoretical level, analysis of modularity - such as K. Ulrich (1995) and C. Baldwin and K. Clark (2000) were described it – produced a few keys enabling an explanation of this phenomenon. Noted characteristics included a decoupling of the design and production functions; the growing separation (and lesser sequentiality) between tasks; a vision of interfaces as cognitive coordination mechanisms; and asset de-specification, something that should theoretically facilitate competition among suppliers (Veloso, Fixon, 2001). T. Sturgeon and R. Florida (2001) offered a good synopsis of the tendencies that seemed to be taking shape at the time.

Even so, some modularity studies stressed that this thinking draws excessive inspiration from an IT model that is actually quite different: computer or electronic products are born modular; whereas the automobile is born an integrated product and must be modularised[5]. This contrast was developed in system integrator studies demonstrating the inappropriateness of this simplified scheme for the complex products found in many industries (Prencipe, Davies, Hobday, 2003). As the systems product par excellence (Clark, Fujimoto, 1991), the automobile belongs to this category (Sako, 2003; Takeishi, Fujimoto, 2003).

Yet despite modularity's imperfection, certain effects do occur. The automobile has its own way of breaking down the modularity concept, namely through macro-components (Volpato, 2004) that are physically compact and multi-functional. This solution has two consequences. Firstly, and contrary to the lessons of (pure) modularity, it is not compatible with the interface standardisation (cognitive field) and asset de-specification (contractual field). This means that there is little hope of imposing a vanishing hand (Langlois, 2003) in the automotive sector. Inter-firm relationships remain dominated by complex modes of coordination (Lung, 2001) such as pragmatic collaborations (Helper,

[5] We are talking about the modern era here since the first automobiles came from the assembly of components purchased from different industries, refuting the hypothesis that they were modular in nature (McAlinden, Smith, Swiecki, 1999). The mass production/vertical integration tandem subsequently drove the automobile product towards a more integrated architecture.

MacDuffie, Sabel, 2000). Secondly, the solution is actually compatible with a pyramid logic and even reinforces it. This is because, as aforementioned, the pyramid logic requires a technical division of labour based on a logic of components interlinked along hierarchical lines. Macro-components pursue this interlinked logic to the extent that it becomes possible to envisage a social division of labour guided by a technical division of labour. This enables the hypothesis of an advanced organisational isomorphism, of the kind explored in modularity research by Sanchez and Mahoney (1996) - even if not all of their justificatory apparatus is relevant to the present analysis.

Table 5 –Traditional design cockpit vs. Modular cockpit

	Traditional Concept	Modular alternative
Part numbers	104	1
Assembly time	22.4 min.	3.3 min
Total cost reduction	Baseline	-USD79

Source: McAlinden, Smith, Swiecki, 1999, p.10

Thus, a phenomenon of aggregation – to wit, the advent of macro-components – is what enabled a reduction in the number of parts being directly purchased by carmakers, while also reducing assembly times and macro-component's overall cost (Table 5). Combined with a multi-sourcing limitation effort aimed at enabling suppliers to achieve economies of scale and at least some systematisation (see below) of their global sourcing, this shift in the object of exchange also led to a reduction in the number of direct suppliers (see Table 4). In parallel, European carmakers were now displaying vertical integration rates that ranged, depending on the model, between 10 and 30%. J. Whitford and A. Enrietti (2005) have shown that between 1982 and 2000, for instance, Fiat's share of outsourced production rose from 50 to 72%, with outsourced design jumping from 30 to 72%. Recent calculations involving the automaking sector showed in France a fall from an already weak integration rate of 16.2% in 2003 to 14.5% in 2007 (Author from INSEE data).

Whereas modularity can be seen as an extension of earlier trends (Sako, 2003) anchored in people's belief in the virtue of downsizing, refocusing on core competencies and the primacy of finance (Jürgens et al., 2002), it also had a strong effect on suppliers. Consequences included a proliferation of merger/acquisition operations; the development of inhouse R&D capabilities (with, for instance, the creation of global research centres focused on upstream issues); strong product innovation (and the proposal of increasingly complex modules); and internal reorganisations converting components divisions into module divisions (Fourcade, Midler, 2005). In reality, what we have witnessed is the creation of mega-suppliers whose vocation is to offer modules and occupy the whole of the supply pyramid's first tier.

1.3. The rise of mega-suppliers

The development of modular production is based on the assumption that a suppliers fabric will be available and capable of undertaking the tangible and intangible investments that come with this supplier-module producer role. In this context, the modular era should enable large suppliers from the previous era to pass a threshold and become mega-suppliers. Automotive News analysis of the world's 100 largest equipment suppliers helps to measure this trend.

Table 9 portrays the cumulative sales of the world's hundred largest suppliers according to their OEM automobile sales. Between 1999 and 2008, sales to carmakers grew by a spectacular 83.8%. In 2008, total equipment and component sales for this group reached USD 607,731 million. One symbol of these companies' growing size is that average sales hit USD 6,077 million in 2008. Along the way, it is also worth noting the effects of the recent crisis, with cumulative sales by the companies in this group falling by nearly 22% between 2000 and 2009.

Table 6 – Total of OEM automotive parts sales by 100 leading auto part suppliers

USD Million	1999	2005	2008	2009	Change 1999-2008	Change 2008-2009
Total of 100 leading auto part sales	330,648.0	512,550.0	607,731.0	474,814.0	83.8%	-21.9%
Median	2,044.5	3,108.5	3,383.5	2,740.5	65.5%	-19.0%
Mean	3,306.5	5,125.5	6,077.3	4,748.1	83.8%	-21.9%

Source: Original data from Automotive News, different years

Examining the trajectory of the world's main equipment suppliers, four phenomena explain the rise of mega-suppliers (for developments in this area, Frigant, 2009; for detailed examples of companies, Klier, Rubinstein, 2008).

There is little doubt that the root cause is market growth, itself a direct consequence of carmakers' vertical disintegration. Note in addition that the companies that grew most quickly during this time were the ones who offered complex module products (Frigant, 2009). Conversely, traditional large special suppliers such as tire manufacturers or glass makers tended to drop in the Automotive News rankings.

A major merger/acquisition trend was encouraged by a dual mouvement: the need to develop the scope of competencies to enable the design and production of increasingly complex elements (modularisation logic); and the opportunity/necessity of internationalising. Here, the modular era can be seen as a direct extension of a previous period in terms of actors' reason for merging – with the aim of developing a global presence becoming even stronger, as witnessed by the growing magnitude of greenfield investments. More and more supplier park sites were being built in carmakers' immediate vicinity due to the significant proximity constraints that are associated with modules (Frigant, Lung, 2002). Alongside of this, equipment suppliers (in part due to pressure from carmakers and/or their shareholders) build an increasing number of facilities in low-cost countries located on the edges of major automobile production zones (Mexico for North America, cf. Contreras, Carrillo, Estrada, 2010; Eastern Europe/North Africa/Turkey for Western Europe, cf. Domanski & Lung, 2009; for a comparison between Europe and North America, Klier & Rubenstein, 2011).

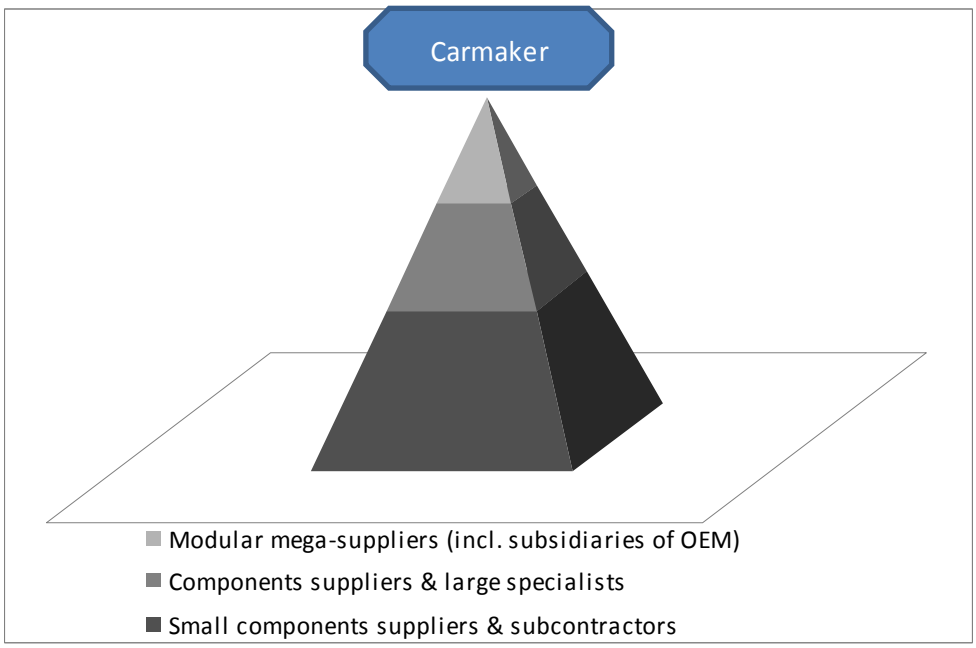
A third point worth noting is that equipment supply subsidiaries were far from having disappeared. Growth in outsourcing was not necessarily accompanied by disintegration, in the capital-ownership sense of this term. American carmakers may well have sold off their large equipment supply subsidiaries (starting with Delphi and Visteon) but their counterparts did not necessarily follow the same path. Not satisfied with being the world's leading carmaker, Toyota is also nowadays the world's largest equipment supplier. In 2009, for instance this Japanese giant held a direct 22.5% stake in Denso, the sector's global leader, while also owning part of Aisin Seiki (the third world supplier according to Automotive News). Hyundai also has some very powerful subsidiaries (including Hyundai Mobis, the world's 12th largest supplier in 2009). Peugeot might be added to this list with Faurecia (global number seven, with the French carmaker holding a 57.4% stake) as can Fiat with Magnetti-Marelli (24th). In short, the idea that a company is engaged in outsourcing can be quite misleading. It remains that the real novelty here is that the subsidiaries in question become more autonomous over time and were encouraged to diversify their customer bases and become fully-fledged profit centres. Of course, in 2010 Denso was still realising nearly half of its total sales with Toyota (for Aisin Seiki the figure was 67.7%) but others such as Faurecia have largely reduced their dependency on their parent company (with Volkswagen having been Faurecia's main customer for several years now). Still, there is no doubt that the growth of these equipment supply subsidiaries has been rooted in their parent company relationships, something that has enabled them to develop their customer portfolios subsequently.

The final element is harder to measure and involves the performance of certain companies seeking to build a product strategy (in the sense given to this term by Boyer, Freyssenet, 2005) that corresponds to carmakers' new expectations. In part, this harks back to the earlier phenomenon of being able to anticipate different forms of outsourcing but doing this now along more qualitative lines. The early 2000s witnessed suppliers deploying different - and divergent - strategies in terms of how they were positioning themselves in the emerging market for modules (Frigant, Lung, 2001). Some (like Magna) wanted to position themselves as quasi-second generation carmakers capable of assembling all major modules used in a car's production. Others focused on accumulating production and research competencies relevant to the key components that they were trying to transform into modules. In all of these cases, suppliers were coping with the problem of having to restructure their product divisions and would tend to hesitate between their initial mission as component makers and the business of a modules manufacturer (Fourcade, Midler, 2004).

In the early 2010s, these mega-suppliers seemed to have completed the construction of the supply pyramid. The market for certain modules appeared to be under the total control of just a few oligopolies[6]. Several specialists asserted that carmakers had lost the competencies they need for the detailed design of certain important modules (Morris, Donnelly, 2006), to such an extent that the reappropriation of such competencies seemed impossible or at least unlikely (Zirpoli, Becker, 2010).

What this means is that the most accurate image depicting a supply chain has mutated into that of an Egyptian pyramid that is very narrow at the top (where only a few mega-suppliers with a global vocation play leading roles) but features, at its lower levels, companies with more of a national vocation carrying out certain production or service activities on first tier companies' behalf. Lastly, beyond these levels this is a vast number of SMEs locked into subcontractor roles. All three tiers are relatively hermetic and there is little hope for a company to move from one tier to another. Figure 1 illustrates this representation.

Figure 1 – Egyptian pyramid



[6] Sutherland (2005, p.243) have offerd a table with market share for several mega-suppliers in the global OEM market: Bosch and Delphi are respectively responsible for 52% and 21% of diesel fuel injection pumps sales; ITT and Bosch for 25% and 31% of all ABS brake systems; GKN for 40% of all constant velocity joints sales, etc. Nolan, Zhang and Liu (2008, p.38) have provided figures indicating the same type of market concentration.

Although the aforementioned developments have helped to forge this representation, we still consider that it is overly simplistic and obfuscates issues that are important for the future of the automotive industry.

II. A more comprehensive metaphor: the Aztec pyramid

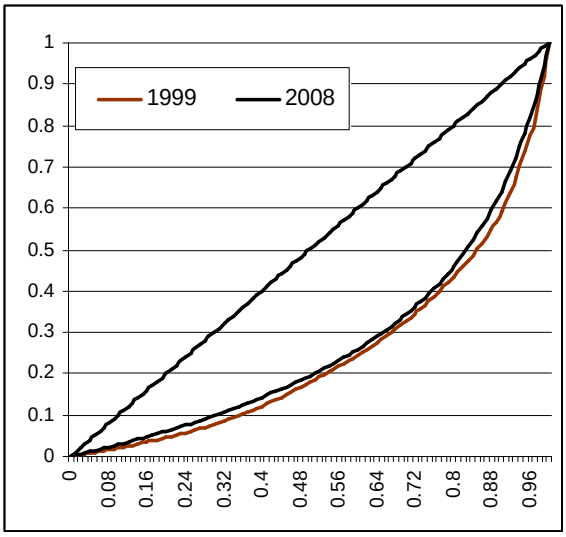
The pyramid representation of the supply chain clearly reflects the reality of this sector's industrial architecture. Criticizing its existence is irrelevant. What - we can try to show, however, is that it is somewhat misleading and neglects several important factual elements.

2.1. Questioning some obvious facts

The presence of oligopolies in a few components market does not mean, however, that all components and equipment purchased by carmakers have fallen under the control of a handful of mega-suppliers. Contrary to certain predictions from the early 2000s (Sturgeon, Florida, 2001; McAlinden et al., 1999), actors in this industry remain very diverse. The march towards modularity has not entirely suppressed actors' reliance on subcontracting nor has it enabled the advent of global sourcing. Carmakers still call upon SMEs for part of their sourcing needs and - alongside the components supplied by a few oligopolies – many continue to source supplies from a large number of firms that are in competition with one another.

One relatively indirect way of measuring this consists of studying the concentration levels found in equipment supplies markets. Using a simple sample comprised of the world's hundred leading equipment suppliers, Lorenz curves moved between 1999 and 2008 somewhat nearer the line of equality (Figure 2). This means that, contrary to popular belief, vertical disintegration did not lead to increased competition in the global market for OEM supplies, thereby benefiting just a few actors. At the same time, we should be clear that for certain components, equipment suppliers did in fact start to enjoy a quasi-monopoly or narrow oligopoly. This indicates that in the fast-growing global market for OEM supplies, actors that are (relatively) smaller in size succeeded in capturing a growing share of total sales.

Figure 2 - Lorenz curves of TOP 100 auto suppliers, 1999 & 2008



Source: Author from Automotive News data

Furthermore, a study of Automotive News's year-to-year global rankings shows significant fluctuations, with 46% of the equipment suppliers work featured in 2009's top 100 having been absent from this elite in 1999. Certainly, some companies disappeared in the aftermath of M&A

operations, but the main lesson is that the structure of the parts market remains highly variable. The positions that suppliers acquire are not totally static insofar as the industry has seen a whole succession of successes and failures.

Another question is what do we call a direct supplier? The question is how these actors should be defined. In the part of its annual report that Renault uses to discuss its corporate social responsibility (CSR) initiatives, the company stated in 2009 that it had more than 800 direct suppliers. But does this mean that Renault had increased its number of direct suppliers since 1997 - or simply that it books them differently? For instance, is it Renault's intention to "oversee" the activities of its tier 1 and tier 2 suppliers in terms of their CSR behavior? Under a similar heading, Peugeot's annual report speaks of its panel audit (suggesting that this is only a sample) of "500 supplier groups and 7,000 service and equipment suppliers" - all of whom are supposed to account for 70% of its vehicle return costs (PSA 2010 annual report, page 16). These figures are also very different from the ones announced a decade before. It may be true that Peugeot's output has considerably increased, diversified and internationalised over this time but the numbers nevertheless seem to translate the fact that what carmakers call direct suppliers nowadays are basically major suppliers producing modules or complex systems rather than the totality of their suppliers. Actually, with the image of a pyramid tending to become the collective representation, we run the risk of only viewing as direct suppliers those actors who produce major components. Note that in this very same annual report, Peugeot states that it has assembled in "300 main suppliers" at a strategic conference. The doubt here is whether these are 300 suppliers of complex modules and subassemblies alone.

This questioning of commonly used data suggests that the problem might be broached from another direction and that suppliers themselves be surveyed. This is the approach that the third part of this section will follow. Beforehand, however, we will analyse how overusing this metaphor has led to certain strategic actors being excluded from the overall analysis.

2.2. One over-simplification: the forgotten (big) suppliers

An initial simplification is the way in which important transversal actors belonging to different tiers have been forgotten: suppliers of raw or pre-transformed materials and ancillary components, on one hand; and engineering companies on the other[7].

The first group of companies is particularly interesting to consider since it often involves very large companies entertaining relatively singular reports with the automotive industry. Examples include suppliers of transformed metals, chemical products (paint, etc.) basic elements (plastic ball bearings) and ancillary components such as chips or sensors.

An initial characteristic of these companies relates to the way in which they have envisioned their own positioning in the automotive sector. These are often multinationals possessing a diversified customer portfolio operating both inside and outside of this sector. It is clear that they might have structured their businesses into dedicated automotive units but this activity is only one among many others. Indeed, from a financial portfolio perspective, this entire business can be considered as one asset among many others. Thus, these are companies that compare the profitability of their automotive activity with their other business lines. The automotive division must be profitable or face the risk of being sold off. This is particularly important to the way in which market relations are structured between buyers and suppliers, given that the firms the question often find themselves in an oligopolistic position.

[7] We might also mention capital goods producers or support service suppliers (logistics, IT) but the present article has taken the conscious step of focusing solely on the supply chain in the strict sense of this term.

A second characteristic is that these companies tend to operate at different levels of the pyramid. They can be in direct contact with carmakers but also with tier 1, 2 or 3 suppliers. Sometimes one and the same company supplies a single supply chain several times. Examples include steel companies supplying chassis carmakers, tier 1 actors in charge of producing car doors plus tier 2 or 3 suppliers producing mechanical items (Jung, 2005).

Neglecting these suppliers seems to undermine general understanding of how supply chains function now and in the future. There are three reasons for this:

1) Market power. These companies' status enables them to put themselves in a strong position to demand high margins. There can also be a quantity effect. For instance, during 2010's strong recovery period phase, some second tier suppliers found it hard to source raw materials and strategic components. As a result, several carmakers' assembly chains had to interrupt output[8]. This meant that competitors with sufficient stocks were able to make progress in markets from which they had initially been excluded. The end result was a redistribution of cards in the hierarchy of suppliers. The resource problems that are bound to arise in the future will inevitably amplify these price and quantity problems. Thanks to their ability to buy in bulk and/or use futures markets, carmakers or mega-suppliers should be able to reconsider their degree of vertical integration or develop material purchasing practices on their own contractors' behalf.

2) A second element pertains to customers' location choices. Generally, even as observers have highlighted the centripetal forces that exist between modular-suppliers and carmakers, they have tended to neglect supplier companies despite the fact that their production plants often represent very heavy investments at the heart of major industrial zones. It is true that many goods (i.e. electronic components) are easy to transport and that the zones in question are extensible. It remains that a barycentric logic continues to apply to transformed products such as steel. The probable future rise in transportation costs could be an obstacle for a certain automotive suppliers thinking about moving to zones where no such companies can be found in the "relative vicinity". Remember that these are companies for whom it is difficult to find good quality raw transformed products in certain countries.

3) A third element relates to suppliers' innovation roles. Such companies are often relatively innovative and capable of product development. However, this also means that they will often require changes in the products that their own suppliers are providing. For instance, innovations in different plastics' properties have helped to alter the breakdown between metals and plastics in automaking. When the supplier of a particular kind of material (i.e. plastic) creates an alliance with an automotive supplier with a view towards greater innovation, this can upset the foundations of the supply pyramid - as witnessed in France with the example of Plastic Omnium, which in just a few years has been able to burnish its role as a tier 1 player in the European industry (Frigant, 2011).

Engineering companies have also been neglected in this pyramid vision. Such firms can involve very small and highly specialised structures featuring very specific competencies that they share with the automotive industry. However, they can also involve larger internationalised companies that often deploy their know-how in a number of different industries[9]. Once again, these are actors who do not necessarily work exclusively for carmakers. They can operate a behalf of first tier suppliers (and more infrequently for lower tier suppliers). According to Dannenberg and Burgard (2007),

[8] http://plasticsnews.com/headlines2.html?id=21002. The March 2011 earthquake in Japan and carmakers and suppliers' subsequent components shortage highlighted the existence of these highly diversified multinationals who produce basic components for the automotive industry.

[9] Literature has barely studied these firms, even though their growth is closely tied to the vertical disintegration trend. For historical quantitative data, it is worth consulting the website of the few exemplary firms, including SEGULA Technologies, The Bertrandt Group, IAV GmbH - Ingenieurgesellschaft Auto und Verkehr, MCA Ingénierie, etc.

engineering service providers make, in 2005, 8% of total automotive RD expenditure (€5.5billion from their own due, €5 billion are projects paid by suppliers and €3.0 billion are projects paid by carmakers). In a general context of vertical disintegration, engineering companies play an important role due to their triple mission:

1) They possess cutting-edge knowledge in different areas and can therefore change cars and modules' architecture;
2) In some instances they will be responsible for the cognitive coordination of actors during development projects;
3) They enable communications between different actors and help to ensure the dissemination of knowledge among employees from different partner companies. Here again (and similarly to materials suppliers), the association between these companies and tier 1 or 2 suppliers can lead a redefinition of the latter's role whenever such collaboration culminates in the invention of new products.

Including these firms does not mean that we need to reject the pyramid vision of industrial architecture. However, we should be fine-tuning our image of supply chains and re-integrate important actors into the analysis, particularly ones destined to assume crucial roles in the future. This remains compatible with Egyptian metaphor except on one point, namely the idea that the pyramid's different tiers are clearly determined. The reason is that these are multi-level actors with a modicum of power to change automobile suppliers' place in the hierarchy. In other words, these companies' presence justifies subtle changes in the otherwise well-structured, well-ranked pyramid vision of branch actors. What remains is the question as to what role SMEs play in this overall vision.

2.3. The forgotten (small) suppliers: Lessons derived from analysis of French automotive SMEs

A second area of investigation is SMEs' role in this pyramid. We are suggesting that analysis at this level should reverse the customary perspective and instead ask questions of carmakers, who are often far too hasty to assimilate direct suppliers with modular suppliers because this makes them sound modern. The study we have conducted is unprecedented in the way that it focuses on suppliers who specifically belong to the automotive supply chain. Undertaken in June/July 2010, it works on two points that are critical of the Egyptian metaphor. Firstly, it notes that a relatively large number of SMEs operate on tier 1, undermining the idea of a market structured solely around modular suppliers. Secondly, actors' position in the pyramid appears more instable than the pyramid vision suggests.

2.3.1. Data and methodology

Our survey started by refusing the presumption that companies belong to a particular supply chain. This is because such approaches always return to the same companies, often (and unsurprisingly) large equipment suppliers. Instead, one of our research objectives was to construct a database for smaller companies working in the automotive industry at different tiers in the pyramid, while potentially also operating in a number of different sectors. Towards this end, we compiled a survey sample from an exhaustive list of companies residing in France and operating in sectors that the automotive industry uses intensively[10]. Subsequently, this sample was filtered to only include companies with less than 5,000 employees and revenues below €1.5 billion[11]. The sample included

[10] The selection of sectors studied here is based on research undertaken by the French National Statistics Institute (INSEE), which books automotive industry purchases on a sectorial basis.
[11] This threshold refers to a specific category of SMEs: ETIs (enterprises of intermediary size).

8,740 companies, with 1,340 having responded, a response rate of 15.3%. After examining these responses, we added the following supplementary criteria: the company must have derived at least 5% of its revenues from the automotive industry; and the questionnaire must be sufficiently thorough to be analysable. Finally, we obtain 750 answers.

Table 7 shows that our database does not cover all of the economic sectors required to produce a modern automobile. Indeed, the survey methodology does not allow us to cover certain sectors due to our inability to identify relevant companies. In addition, in certain cases we did not receive any responses. One example here was technical textiles, where none of the companies we wanted to survey replied. It remains that the crucial sectors were all represented. Metallic products manufacturers are best represented in our database - an unsurprising outcome given this sector's importance to the automotive business. Another major sector is automobiles themselves (referring here to manufacturers of automotive equipments). Then came two sectors (combined for our purposes); IT, electronic and optical product manufacturers (especially the latter two); and electrical equipment suppliers. Lastly, note the small number responses from engineering companies. This can be explained by the fact that very few small actors operate in this particular field in the French economy (remember that the report specifically covers SMEs).

Table 7 – Suppliers' sector of origin

Sector (aggregate level)	*% of suppliers*
Automobile (equipments)	17.1%
Manufacturing of IT-related and electronic products/optics or electric equipment	12.8%
Capital goods	6.3%
Engineering	0.8%
Manufacturing of metallic products	56.8%
Metallurgy	2.7%
Manufacturing of rubber and plastic products	2.5%
Manufacturing of other mineral non-metallic products	0.9%
Number of suppliers: N=750	100%

Source: OSEO (2011)

All in all, the sample is not entirely representative of the companies mobilised by automakers and automotive equipment suppliers. However, it does provide a good basis for further study. When we compared our data with figures provided by French automotive industry associations, what became clear is that they estimate the number of suppliers residing in France at something like 4,000. Thus, our database represents 18.7% of suppliers identified by actors in this branch (18.1% in revenue terms).

Companies belonging to the sample generate average revenues of €9.48 million with a median figure of around €1.60 million. Globally, therefore, these are relatively small companies, as confirmed by the average number of staff members as of December 2009: 52.6 employees. This average is further lowered by the fact that 36% of the sample companies have fewer than 10 employees. At the other extreme, 5% have more than 250 employees (with the largest having 1,430 staff members). Note that the tables below will indicate the thresholds we used (250; 1,500). In terms of French industry as a whole, "large" SMEs are over-represented in our database, something that can probably be explained by the automobile's "mass industry" aspect.

Our survey method contained one risk, namely that we would select companies with little relationship to the automobile. The breakdown of the revenues generated by our sample companies by their target customers offers some reassurance along these lines, however. On average, 77.7 percent of sales were in the automotive sector, whether this involved firms working on tier 1, 2 and 3

(and beyond) or spare parts markets[12]. Lastly, a final specification for this discussion of our sample (readers can find more information in OSEO, 2011) is that we are studying companies that reside in France, which can involve foreign companies that have set up operations in France. Although the database does not reveal the nationality of the company in question, its can be assumed that we are mainly dealing with French companies since 75.7% declare that they are independent (with the others saying that they are members of financial or industrial groups). Nevertheless, it should not be concluded that these are companies that only work for the French automotive industry. After all, exports account for 14.1% of their total sales – a relatively high rate, compared with the whole of the French economy and given the significance of micro-enterprises. Also, among companies with more than 250 employees, the export rate reaches 46.1%. It is 29.6% for companies with between 50 and 249 employees and 12.8% for companies with between 10 and 49 employees.

Table 8 – A few descriptive sample findings (2009)

	Number of suppliers	Total	Mean	Median
Sales (€000s)	747	7,081,773	9,480.3	1,600
Employees	749	39,432	52.6	15
Total sales/auto. sales (%)[1]	716	-	77.7%	100%
Exports/sales (%)	729	-	14.1%	3%

20% of suppliers do less than 30% of sales in automotive sector; 6%∈ [31, 60[; 7%∈ [61, 90]; 67% > 90%.
Source: OSEO (2011)

Without being perfect, the database constitutes an original tool for studying the current situations of French SMEs working in the automotive sector. Notably, it allows us to show that these companies are not in fact really being excluded from the supply pyramid.

2.3.2. Yes, SMEs can be first tier suppliers

Thanks to the question asking companies to break revenues down by their tier of supply chain involvement, we could verify whether, in 2009, the SMEs that we studied were or were not excluded from the first tier in the pyramid.

There are two ways of reasoning at this level. We can consider this as the main tier where these companies operate - or else, as the highest tier that they mention. It is true that a company can operate on several tiers simultaneously. Therefore, the first measure consists of taking the highest percentage of revenues. For instance, a company stating that it achieves 10% of its revenues on tier 1 and 20% on tier 2 will be mainly considered as a tier 2 supplier. The second method, which consists of taking the highest tier that a company mentions, would mean that we would consider it a tier 1 supplier.

Table 9 – Suppliers' position in the pyramid (N=715)

	Tier 1	Tier 2	Tier 3 and more	Spare parts	Total
Main tier	25.9%	47.8%	21.7%	4.6%	100%
Higher tier	35.5%	45.5%	16.1%	2.9%	100%

Source: OSEO (2011)

Table 9 shows that the most frequently mentioned tier is 2: 47.8% of all respondents' prime supply chain intervention is at this level, with 21.7% operating on tier 3 or further down and only 4.6% stating that their main link to the automotive business is their spare parts activity. It remains

[12] Companies had to break total revenues down between "automotive" and "non-automotive". For "automotive", revenues had to be broken down by counterparts' level of intervention in the supply chain. This is crucial for the elimination of irrelevant questionnaires and underpins the subsequent analysis.

that the key finding for our analysis is that nearly 26% of all the SMEs that we surveyed are first tier suppliers.

This initial approach can be usefully supplemented by a second one where, rather than focusing on the tiers that a company usually occupies, we asked questions about the highest tier that they would declare. By construction, this should give us a higher number of companies situated toward the top of the pyramid. According to this second approach, 45% of SMEs operate at the level of tier 1, and 16.1% on tier 3 and below. Only 2.9% are attached to the supply chain exclusively because of their spare part market activities[13]. Of course, 35.5% of the SMEs that we studied stated that they conduct some of their activities directly on automakers' behalf.

This change in focus has only a slight effect on our snapshot. Although we can confirm that the SMEs that answered our survey are primary the tier 2 suppliers, it remains that a significant number of these companies are also first tier suppliers. Clearly, this does not mean that SMEs account for a lion's share of the market for outsourced components. We cannot deny, however, that mega-suppliers account for the largest orders (in volume and value terms). Similarly, we accept that a response bias exists and that the companies who respond to a survey are more likely to be ones who feel close to carmakers. Nevertheless, even if we accept that these figures might be biased in magnitude terms, they still demonstrate that vehicle manufacturers remain accessible to SMEs. The OEM market is not an exclusive hunting ground for mega-suppliers.

As such - and in terms of the controversy between Herrigel and Sturgeon/Florida - these findings tend to support the former's position. This suggests that far from being an infancy issue, the modularisation of the automotive business has not completely relegated SMEs to the bottom of the pyramid.

Note, however, that among this group of SMEs there is a relatively clear relationship between size and the main tier where they intervene in the supply chain (Table 10). The large SMEs featuring in the sample achieve most of their automotive-related revenues either on tier 1 (70%) or tier 2 (30%). This relationship between size and tier also applies to companies with between 50 and 249 employees because 35.4% of all respondents operate mainly on tier 1, 52.1% on tier 2 and 7.3% on tier 3 or beyond. Similarly, companies with 10 to 49 employees are mainly active on tier 2 (52.1%). Only 21.0% of them operate mainly on tier 1 and 22.5% on tier 3. This downwards movement also applies to micro-enterprises since 43.3% are mainly tier 2 suppliers and 29.8% mainly tier 3 suppliers.

Table 10 – Main tier in 2009 by supplier size

Number of employees	Number of suppliers	*Tier 1*	*Tier 2*	*Tier 3*	*Spare parts*	*Total*
[250; 1500]	40	70.0%	30.0%	0.0%	0.0%	100%
[50; 249]	96	35.4%	52.1%	7.3%	5.2%	100%
[10; 49]	334	21.0%	52.1%	22.5%	4.5%	100%
< 10	245	21.6%	43.3%	29.8%	5.3%	100%
Total	715	185	342	155	33	-

Source: OSEO (2011)

2.3.3. No, the hierarchy is not as straightforward as it seems

This pyramidal vision of the supply chain contains the idea that a certain hermeticism exists between different tiers. The restructuring of the industrial architecture is said to have led to

[13] By construction, these companies do not operate in tiers 1, 2 or 3 since they would have been ranked in one of the preceding tiers.

companies being clearly positioned at one and only one tier in the hierarchy. Variances between different lines in Table 12 suggest to the contrary that a number of multi-level companies do exist. To explore this possibility, we have listed companies according to whether they state their automotive revenues in terms of one or several tiers (Table 11).

Table 11 – Breakdown of suppliers by number of tiers where they operate (2009)

One tier suppliers		Multi-tier suppliers	
(N=432)	60.59%	(N=281)	39.41%
First tier alone	12.9%	2 tiers	30.9%
Second tier alone	30.4%	3 tiers	7.6%
Third tier alone	14.7%	4 tiers	1.0%
Spare parts alone	2.5%		

Source: OSEO (2011)

Most companies are only operating at a single tier of the hierarchy (60.6%). 30.4% of all SMEs are second tier suppliers and nothing else. 14.7% and 12.9% of SMEs are tier 3 or tier 1 suppliers alone. 2.5% of SMEs are spare part suppliers alone. These findings seem to support the hypothesis that suppliers' roles are split across the whole of the supply pyramid. It remains that the fact that 39.4% of all companies operate at several tiers simultaneously in one and the same year (remember that these are snapshot statistics) suggests a different interpretation of the data, namely that companies' positioning in the hierarchy is less strict than might be assumed with analyses conducted in pyramid terms. Nearly 31% of SMEs operate on two tiers simultaneously and 7.6% operate on three tiers simultaneously. The example drawn here of companies operating on all three of the pyramid tiers (and who also supply spare parts) is, however, very rare and only accounts for 1% of all suppliers.

Table 12 shows that multi-tier companies' most frequently observed combinations are between neighbouring tiers and combine two levels. Out of the 281 multi-tier SMEs, 31.0% operate simultaneously on tiers 1 and 2, with 29.2% operating simultaneously on tiers 2 and 3. Another frequent combination consists of supplementing one's direct involvement in the supply chain by the manufacturing of spare parts. This is the case for 8.5% of tier 2 suppliers and 5.3% of tier 1 suppliers. 6% of multi-tier suppliers intervene on tiers 1 and 2 and also manufacture spare parts. Lastly 10.7% of multi-tier companies (or 4.3% of all SMEs) operate on tiers 1, 2 and 3.

Table 12 – Distribution of combinations for multi-tier suppliers

Tiers occupied simultaneously	
Tiers 1 & 2	31.0%
Tiers 2 & 3	29.2%
Tiers 1 & 2 & 3	10.7%
Tiers 2 & spare parts	8.5%
Tiers 1 & 2 & spare parts	6.0%
Tier 1 & spare parts	5.3%
Other combinations (4 possibilities)	9.3%
Total	100%

Source: OSEO (2011)

All in all, whereas a majority of SMEs taking part in the supply chain intervene on one single tier alone, it is important to avoid the conceptual trap that consists at this level of considering that the pyramid in question has been structured once and for all. Crossover possibilities do exist between different tiers. Many companies are simultaneously present on several different supply chain tiers.

We have already demonstrated that size is an important element for explaining the tiers that SMEs occupy in the pyramid. We can, however, transcend this simple analysis by considering the nature of the services that suppliers offer. In the questionnaire, we asked suppliers to describe the services they fulfil on behalf of the automotive industry. These are qualified by two elements. Firstly, the characteristics of the elements provided (with engineering companies being eliminated from this database); a distinction is made between simple and complex parts (the latter defined as subassemblies derived from the assembly of different components). We then asked companies whether a research and/or development activity was involved. Combining the two, we were able to construct Table 13.

Table 13 – Tier(s) occupied in 2009, by services provided

	Only Tier 1	Tier 1 + another tier(s)	Only Tier 2	Tier 2 + another tier(s)	Only tier 3	Only spare parts	Total
Simple parts	10.5%	15.6%	34.2%	17.3%	19.8%	2.5%	100%
Complex parts	10.8%	26.2%	24.6%	21.5%	15.4%	1.5%	100%
Simple parts + R&D	12.1%	31.2%	29.1%	17.7%	9.9%	0.0%	100%
Complex parts+ R&D	21.0%	36.0%	24.0%	11.0%	7.0%	1.0%	100%

Source: OSEO (2011)

We retain two essential ideas at this level. The first is that, all things remaining equal, the more complex the service being provided, the greater the probability that the actor in question will be operating towards the top of the hierarchy. The first major distinction here is between complex and simple parts. The former tend to be made by suppliers positioned on the first tier. Adding R&D services increases the probability of becoming a tier 1 supplier, whether exclusively or partially. Conversely, suppliers manufacturing simple parts tend to be situated towards the bottom of the pyramid.

The word “pyramid” is not being used by happenstance. The table suggests that there is indeed a form of hierarchy within this category of SMEs. What we find here is more or less a breakdown between the different kinds of logic underlying the pyramid architecture such as it was described in section 1 above. Nevertheless, the data also shows that: this pyramid is not totally grounded in a company size logic; carmakers continue to purchase simple components; and multi-tier SMEs do in fact exist.

The presence of these multi-tier companies can be explained by the fact that suppliers are able to alternate from one tier or contract to another. Far from having created a static hierarchical structure, modularity perpetuates forms of rotation (Herrigel, 2010). One explanation lies in most products’ technical breakdown, which tends to be less stable than it first appears. L. Gadde and O. Jelbo (2002) have explained that carmakers vary greatly in the design of their vehicles’ physical breakdown. JJ. Chanaron (2001) agrees with this point and shows that the modularity approach adopted by Western carmakers differs from the path followed by their Japanese counterparts. In other words, it is the chronic instability in product architecture that prevents the market for components, systems and modules from stabilising. In addition, it is worth noting the frequent disappointment of those equipment suppliers who wager on the modules market ever achieving a stable structure (Fourcade, Midler, 2005) – they have often had to re-orient towards kinds of organisations allowing them to offer modules/macro-components even as they seek to maintain their status as components makers (Herrigel, 2010). Like the aerospace product (O’Sullivan, 2006), automotive interfaces are still very unstable and force carmakers to redefine their architectures from one model to another.

Another problem derives from the internationalisation of production, with global sourcing remaining a difficult point at this level. Sometimes, when the goal is to produce one and the same vehicle in different factories, carmakers are forced to adapt its elements either in reaction to the specificities of the local supplier fabric or else because they want to adapt to the local market, causing them in turn to restructure the equipment they demand (see Herrigel, 2010; Humphrey, Lecler, Salerno, 2000). A carmaker X embarked upon an internationalisation process has even been able to systematically re-design its general architecture and components in sync with its deployment of production overseas to such an extent that the outsourced elements have ended up being strongly differentiated from one country to another. Said carmaker does not rely systematically on mega-suppliers engaged in a follow sourcing process. Some of the elements are sourced directly from smaller companies found in the countries where its plants are located (Ref. forthcoming after authorisation).

De facto, this pyramid representation is tantamount to an abbreviation. It is a metaphor where the automobile is depicted as an aggregation of different complex components that can themselves be broken down into subassemblies that are less complex in nature. Yet this quasi-fractal vision of things is only partially valid. It is true in the sense that efforts to modularise the automobile product have led to an amplification of this kind of branch structuring effort, epitomised by the creation of macro-components (Volpato, 2004) that are modules directly integrated into carmakers' assembly lines. These result from an aggregation of different subassemblies that can themselves be broken down into elementary components[14]. The vision is imperfect, however, since contrary to the description provided by the GM Vice President who stated that modular automobiles are "like the definition of a Lego set" (*Financial Times*, 28 January 2004, cited in Klier, Rubinstein, 2008, p.18), the automobile is not (yet) the same thing as a Lego set. As K. Pavitt notes (2003), we do not live in LegoLand. In addition to macro-components, many different elements and services are still being directly purchased by carmakers. In addition, the standardisation of components - notably when we think about the internationalisation of production - is still very imperfect. Things still have to be adapted. Given this double constraint, there is still room for SMEs to have direct access to carmakers.

[14] In a study seeking to understand mega-suppliers' location strategies, Frigant and Layan (2009) make a distinction between macro-components, meso-composants and composants.

Conclusion

The purpose of this article has been to raise questions regarding the customary description of automotive supply chains' industrial architecture. Analysis of transformations in supply chain since the 1980s has led to this architecture be represented using a pyramid image. With today's focus on understanding the issues associated with transformations in this field of activity, we often end up describing a very hierarchical supply chain characterised by entirely hermetic tiers where companies throughout the pyramid are positioned by their size. It is true that this is an informative image that helps us to understand many ongoing processes.

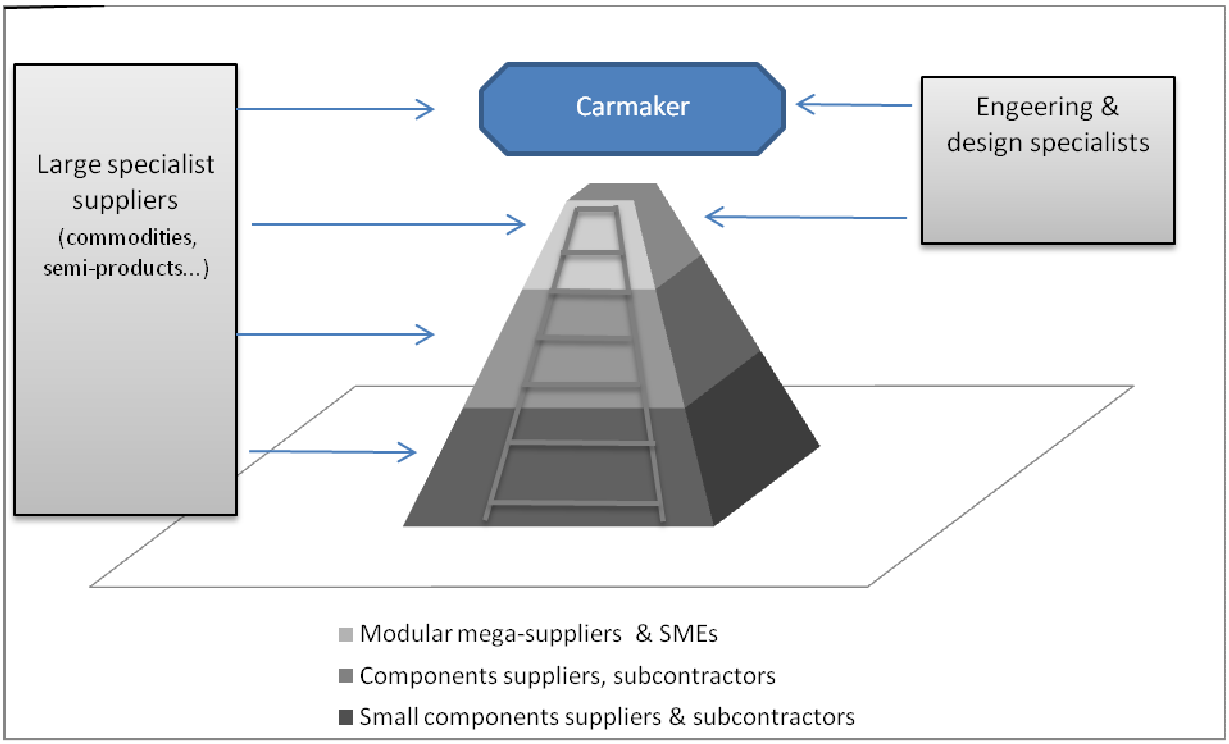
It remains that it is also a simplification that does not really stand up to the test of empirical analysis. As much as we consider it useful to employ the Egyptian pyramid metaphor, we also need to do better since it is a description that neglects far too many crucial realities.

Firstly, it neglects important and crucial actors across the pyramid who can be subject to a great deal of pressure: large producers of raw materials and semi-transformed products as well as manufacturers of key components that can originally be very remote from the automotive business. Not to forget the engineering companies that constitute an interface between carmakers and suppliers and who owe much of their development to the rise of modularity.

Secondly, this metaphor suggests that SMEs are condemned to fall to the bottom of the pyramid because they do not have the means to operate on a global sourcing basis and cannot compete in the race to modularise. Clearly, a number of researchers (such as G. Herrigel back in 2004) have contested this vision but questions remain whether it links to the novelty of the modularisation process and whether, over time, SMEs might be drawn into an unavoidable decline. The survey of SMEs operating in different supply chains has provided a solid empirical proof corroborating Herrigel's qualitative analysis. It confirms that certain SMEs retain direct access to carmakers and that the borders between the different tiers are not entirely hermetic. All in all, we want to keep this pyramid metaphor but feel that the industrial architecture of supply chains in Europe is more redolent of an Aztec pyramid than an Egyptian one. At the very least, it is less focused on a few mega-suppliers operating towards the top and features staircases along its sides that enable actors to ascend and descend easily depending on the relationships they entertain and the products they manufacture (Figure 3).

Clearly, this whole undertaking remains a work in progress, first and foremost because we need to re-assess the role that large module suppliers play. The vocation of these actors may be to assume a tier 1 position but they might also intervene on tier 2, if only because they still have components divisions that can be mobilised by other suppliers who act as tier 1 actors where a particular vehicle is concerned (Herrigel, 2010). This whole aspect deserves more systematic research. In addition, it might be beneficial to include other geographic regions in the analysis. Supply strategies vary depending from one carmaker to the next and it could be useful to study how they materialise in industrial architecture terms. The perspective chosen for this article - at least in section 2 - is fundamentally supplier focused. This could be reversed so that questions about architecture might be raised from carmakers' perspective.

Figure 3 –Aztec pyramid



Lastly, the analysis could also be extended to other sectors. After all, the automobile has often served as an ideas laboratory for other industries, and the same applies to the idea of a pyramid architecture. For instance, it is clear that aircraft manufacturers have also drawn inspiration from this principle when they began their vertical disintegration (Frigant, Talbot, 2005). The aircraft supply chains are nowadays described in relatively similar terms and the desire to structure suppliers into a tier arrangement recurs in many observers' narrative (Kechidi, Talbot, 2010; Kechidi, 2008). It remains that this similarity may also be only apparent. In addition, the complexity of the architecture displayed in the automobile sector may be solely based on the intrinsic limitations of carmaker's desire to organise supply chains around modular mega-suppliers. The automotive industry might still have a few tricks to teach other industries.

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