AUTOMOTIVE SUPPLIER INTEGRATION FROM AUTOMOTIVE SUPPLIER COMMUNITY TO MODULAR CONSORTIUM

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Introduction

There is significant ambiguity in explaining current supplier integration models in automotive industry. The phenomenon shows considerable variation by region and vehicle manufacturer. While several contributions on the motives for logistics supplier integration have been made, no consistent typology offering objective criteria and scales for classifying logistics integration scenarios exist to date (Reichhart and Holweg, 2008). The purpose of this paper is twofold. First the main contribution of this paper lies in systematically comparing the existing logistics integration models for suppliers and second to evaluate existing logistics conditions and their national and corporate differences in current auto logistics operations.

This paper uses a literature review of research and practitioner articles to survey integration models in theory and practice. In addition data is collected through semi-structured interviews of key operations executives at German, Czech and British suppliers and vehicle manufacturers.

Supplier Integration

The ability to control and synchronise a firm´s supply and logistics operations has been critical to operations strategies ever since the start of the twentieth century, when Henry Ford opened the fully vertically integrated River Rouge complex, which included operations from raw materials to finished cars (Reichhart and Holweg, 2008). Automotive Manufacturers are increasingly realising that improved supplier integration leads to improved performance for the supply chain as a whole. The broadest integration strategies lead to the highest rates of significant performance improvements (Harrison et al., 2008).

Research for this paper has identified within the UK Automotive sector a shift in the “outsourcing” concept of product assembly undertaken by selected suppliers at the tier-0.5 and tier-1 level to Condominium Assembly. Constant evolvement of the synchronous supply process is ongoing between vehicle manufacturers (VM’s) and tier-1 suppliers from supplier parks through module assembly and delivery to Condominium Assembly and beyond to Modular Consortia.

Drawing upon previous case experience and other recent relevant research, this paper develops a series of factors that are likely to influence the degree of success possible with this latest approach across automotive comparison logistics conditions (Figure 2). It also looks at the likely consequences of the supply options available and draws lessons from the research experience.

There is an evolving scenario for modular organisational development where both VM’s and suppliers need to agree and follow both a technological and an organisational template (Morris et al., 2004) for production operational efficiency. Some observers have stated that as the Supplier / VM integrated role appears to have become permanent in organisations it might well be prompting new forms of organisations to emerge (Cavinato, 2005). However, Holweg (2005) has suggested that specific types of flexibility need to be explored in relation to the particular settings of each supply chain to fully exploit the competitive potential. For example, some component suppliers have been transforming themselves into module suppliers not offering only a narrow manufacturing expertise but a holistic service solution (Kemppainen and Vepsalainen, 2003).

Transfer of organisational capabilities from the customer to the supplier requires a governance structure that facilitates long-term cumulative learning (Sako, 2004). Also, Svensson (2004) has suggested that the competitive business environment in the automotive industry has forced VM’s to improve their relationship strategies towards their suppliers. It is now considered that the automotive industry has focussed on optimising the VM and their tier-1 suppliers (Hines et al., 2004).

The Condominium model identified from primary research, requires suppliers of assemblies and modules (larger assemblies of vehicle “components”) to produce their product in-house of the vehicle manufacturer and adjacent to the main production line. This manufacturing technique reduces transportation of the finished product from supplier production facility to customer handover to a distance of "several metres" by AGV (advanced guided vehicle). The customer takes delivery of the supplier product directly onto the main assembly line, thus supplier product hand over is taken at the production line and in person from the supplier to the customer. However further research into the European Automotive Industry has revealed a further Consortium situation to a full Modular Consortium Integration (Table 1).

The adoption of modular assembly in the UK Automotive Industry has led to a more efficient usage of an automotive manufacturer's production facility floor area. By in-sourcing a select group of Tier 0 module producing suppliers to manufacture Front End, Cockpit Module and other assemblies adjacent to the car production assembly line, a UK Vehicle Manufacturer (VM) has created a more efficient automotive production operational network in close co-operation with their main suppliers.

Lamming *et al*. (2000) considered that the incorporation of the term 'network' into supply chain management was an attempt to make the supply chain wider and more strategic by embracing more effectively the potential of the network. They argue that, the first tier supplier is generally not comfortable with the VM's supply chain management due to the VM's possible short-term focus on supplier development activities. This also implies that the knowledge flow is mostly one-way i.e. supplier to VM. The supplier also feels that little strategic information is disclosed concerning new products and technology changes which could render the supplier's product obsolete. Many suppliers positioned further upstream (i.e. above traditional tier-1) have asked for more joint activities with the VM, suggesting that suppliers want to be more involved in the improvement of the VM's products.

Das (2004) suggested that an important business feature is the formation of strategic alliances, aimed at achieving mutual strategic objectives. To reduce costs without impacting on the product or service, organisations have focussed on technique's to manage operations beyond their organisational boundary. This has created a more holistic and integrated approach taken by leading organisations in developing the supply strategy concept (Harland *et al*., 1999). Additional research by Das and He (2006), identified that researchers have observed that strategic alliances between entrepreneurial and large firms are especially problematic.

Das and Kumar (2007) suggest that with combined strengths of the alliance, partner – specific learning is critical in determining whether or not an alliance is formed. Inter-firm alliances have become more common due to globalisation, deregulation, and the fast pace of technological change, which enables firms to share the costs of R&D development, expedite the introduction of new global products; minimise costs; gain access to resources and new technologies of partner firms. Das (2005) also considered that the threat of any deceitful behaviour would hinder the collaborative efforts of the member firms of an alliance. It would also destroy inter-partner trust and confidence and lead, eventually, to the termination of the alliance.

Methodology

A main aim of this research was to identify the latest focus key issues and implications in connection with synchronous in-house supplier assembly and associated product supply to a UK VM's assembly plant. The use of semi-structured interviews was considered to be the most appropriate technique for data collection and viewed as a valid medium in which to gain real world knowledge (Yin 2003).

Using a case study approach, the detail behind the introduction of the Condominium Assembly integration explores a new central controlling position for case study VM manufacturing divisions placed at the centre of their automotive supply chain efficiency. Saunders et al. (1997) considers pattern-matching involving the prediction of a pattern of outcomes based on the theoretical propositions to explain what the researcher expects to find; this includes collecting data and analysing the data via explanatory case studies, which is a consideration made to the case evaluations within this paper.

Semi-structured interviews were considered to be the most suitable data collection technique as access was given for interviews to take place with each respondent which lasted approximately 90 minutes. The intention here was to gain a real world understanding of automotive industry best practice in synchronous supply possibilities in practice. Observation of the facilities was given at all the organisations interviewed in the UK with the exception of the tier- 2 Fastener supplier.

A main aim of this research was to identify the important issues associated with a tier-0 supplier situation within the UK Automotive Industry. With this aim, six case study organisations were identified as supply chain positioned and linked. The responding organisations were as follows:

- A Global UK Vehicle Manufacturer incorporating tier-0 Suppliers [Key respondent Senior Controller]
- A tier-0 Supplier of Cockpit Modules to the case VM [Key respondent Operations Manager]
- A tier-0.5 Module Supplier to the case VM and case tier-0 supplier [Key respondent Commercial Manager]
- A tier-1 Supplier of Major Product Assemblies [Key respondent Commercial Manager]
- A tier-1 Sub-assembly Supplier [Key respondent Operations Manager]
- A tier-2 Supplier of Fastener Products [Key respondent Commercial Manager]

Automotive Supplier Integration Model

All integration types are different forms of supplier clusters. A cluster is defined by Porter as a geographic concentration of interconnected companies and institutions in a particular field (Porter, 1990). The investigated supplier integration models can be separated from general supplier clusters that all integration types are based on a strategic decision of one or more original equipment manufacturers. Vehicle manufacturers and their supply chain partners have developed many different logistics solutions. A seven-step integration model was developed which will allow for a categorisation and comparison of existing solutions.

Integration Type	Full Modular Consortium	Partial Modular Consortium	Condominium	Supply Centre	Adjacent Supplier Park	Regional Supplier Park	Automotive Supplier Community
Assembly work in the main assembly track	Tier-1 supplier	VM/ Tier-1 supplier	VM	VM	VM	VM	VM
Number of supplied OEMs or OEM plants	one	one	one	one	one	one	more than one
Supplier distance to final assembly track	positioned on the final assembly track	positioned on the final assembly track	positioned at the final assembly track	on the production site close to the assembly hall	off but very close to the production site	based in the production site region	based in the production site region
Site owner	VM	VM	VM	VM/LSP	Investor/ Community	Investor/ Community	Investor/ Community
Examples:	• MAN (former VW) Resende (Brazil)	• Smart Hambach (France)	• Ford Camaçari (Brazil) • Nissan Sunderland (UK) • Skoda Mladá Boleslav (Czech Republic)	• BMW Supply Centre Leipzig (Germany) • VW Production Supply Centre Hannover (Germany)	• Audi GVZ Ingolstadt (Germany) • Ford Saarlouise (Germany) • VW Palmela (Portugal) • GM Blue Macaw Gravataí (Brazil)	• VW Industrial Park Lozorno (Slovakia)	• BMW Wackers-dorf (Germany) • Automotive Supplier Park Rosslyn (South Africa)

Table 1: Logistics Supplier Integration Model

Integration Step 1: Automotive Supplier Community

The loosest type of logistics integration is the automotive supplier community. This is a dedicated co-location of suppliers in the region of dedicated vehicle manufacturers. The big difference to all the other integrations types is that deliveries are made to more than one vehicle assembly plant. Such a scenario can occur if different vehicle manufacturers are locally concentrated or an OEM has more than one assembly plant within relatively short distances and would like key suppliers to locate in a dedicated area close to all of those assembly plants (Reichhart and Holweg, 2008).

An example for more than one OEM plant is the BMW Innovation Estate in Wackersdorf where several external and internal suppliers provide the BMW plant in Regensburg (distance 50km) and Dingolfing (distance 130 km). Also other BMW sites in Munich (distance 160 km) and Leipzig (distance 300 km) are integrated in the supply network via Wackersdorf. A worldwide unique example for a multi-OEM supply is the Automotive Supplier Park Rosslyn in South Africa. The supplier park is based close to the production facilities of BMW (3,3 km), Fiat (1,3 km), Ford (35 km) and Nissan (1,3 km). 13 suppliers with more than 4400 employees supply four different vehicle manufacturers and further national and international customers.

Integration Step 2: Supplier Park
In order to reap the benefits of proximity with their major tier-1 suppliers, many vehicle manufacturers have made arrangements with the local authorities to create supplier parks adjacent to or at least nearby their productions sites. Often the infrastructure investments are carried jointly between investor groups and the local community. (Jürgens, 2003).

A supplier park is a cluster of suppliers located outside but close to a final assembly plant. In the past years more and more just-in-sequence suppliers settled down in supplier parks. Usually associated with new assembly plants, the parks are located very near to factories, and inhabited by a variety of suppliers. The suppliers maintain either full manufacturing operations or just low value-adding tasks like pre-assembly with late configuration and feed parts to the line on a demand led basis, and often at very short notice. More and more logistics service providers are integrated and offer a range of services, such as light assembly and sequencing, to firms that do not maintain local manufacturing operations (Reichhart and Holweg, 2008). Adjacent supplier parks are linked with conveyor belts, tunnels or bridges with the final assembly track of the OEM. By contrast regional supplier parks deliver over longer distances by truck.

Integration Step 3: Supply Centre
Supply Centres are co-located supplier clusters on site. Buildings and equipment are either fully invested by the OEM (e.g. BMW Leipzig) or partially invested by vehicle manufacturer and logistics service provider (e.g. VW Nutzfahrzeuge Hannover). In the former case the vehicle manufacturer makes its on site infrastructure available to its suppliers. All suppliers and logistics service providers are just tenants on location, so there is still enough flexibility for the VM to change partners. The proximity of suppliers enables a late module configuration in the supply centre with a smooth material flow. The stable material flow, with concentrated suppliers in short distance on site, enables the automation for line side delivery. So BMW Leipzig for instance uses an electrical conveyor system to connect external and internal suppliers between the supply centre and the final assembly line.

Figure 1: Supply Centre BMW plant Leipzig (Source: BMW AG)

Integration Step 4: Condominium
The condominium approach goes a step further in integration. In this case, suppliers reside and operate under the same factory roof as the vehicle manufacturers. Due to outsourcing and lean management OEMs often do not need the space adjacent to the final assembly track any longer and therefore offer part of their factory space to suppliers (Jürgens, 2003). Although in many cases OEM

plants especially brown-field sites lack enough adjacent free floor space to install an in-house supplier assembly. In condominium suppliers assemble their own modules inside the assembly area, which are then fed into the assembly line using small buffer stocks, to performing the final vehicle assembly. All vehicle final assembly work is done and controlled by the OEM of its own. The suppliers are not responsible for fitting their modules on the final assembly line, but some of them employ a quality check person at the point of fit, indicating the need for seamless coordination of assembly tasks that cross the boundary of the firm. One example for a condominium is the Ford Industrial Complex at Camaçari, in the state of Bahia in Brazil. In 2004, the so-called Amazon project employed 7753, of whom 3372 are just on Ford´s payroll (Sako, 2006).

Integration Step 5: Modular Consortium

Modular consortium is the highest possible integration step for suppliers in automotive industry. The whole assembly operation is divided into separate modules, with a supplier responsibility for each. All direct workers are paid by the suppliers. Therefore the suppliers not only assemble the modules, but also perform the final vehicle assembly. At the full modular consortia type the vehicle manufacturer focuses on planning, design, engineering, quality assurance, coordination and administration (Harrison et al., 2008). The OEM is not involved in the assembly operations but is responsible for the final inspection of the completed vehicles.

The most prominent examples of modular consortia is the MAN (former VW) truck plant in Resende (Brazil) and the Smart assembly plant in Hambach (France). At Resende, this supplier integration model in terms of employment leaves the OEM in a minority position. Out of the 2118 people working at the truck plant in Resende in 2004 only 477 were OEM employees. The OEM staff work in functional offices overlooking the main assembly line, responsible for product development, purchasing and process engineering in order to tightly control process engineering in its body shop, paint shop, and final assembly (Sako, 2006). Whilst at MAN Resende as a full modular consortia type all final assembly work is done by suppliers, the Smart plant in France is an example for a partial modular consortium where final assembly work is shared between VM and suppliers. So for Hambach the final assembly line starts within the area managed by Continental, which assembles the cockpit module and fixes it onto the body frame. Thereafter, the final assembly line is managed by Smart (Sako, 2005). Finally the retention of final assembly work is a matter of OEMs strategic choice.

<u>Differences in logistics conditions</u>

Differences that can be seen between the logistics conditions of the discussed supplier integration models are geographical proximity, shared investment, asset specificity, IT-system integration and transport costs.

The further the integration the closer suppliers and vehicle manufacturer are together. The close integration of suppliers allows an optimisation of inbound delivery and material handling combined with less investment in transport assets (Jürgens, 2003). Proximity matters here because local rivalry among automotive suppliers with known identity creates a better motivational force for competition than faceless competition (Sako, 2003). Beyond competition there are also examples of situations in which otherwise competing firms were co-operating. Close proximity carries a significant potential for synergies in the form of shared services and investment. Geographical supplier proximity depends on the local value-added content of the suppliers (Reichhart and Holweg, 2008).

Asset ownership is outsourced in most cases of supplier integration to economize on overhead and fixed costs by sharing them with suppliers. There is just a tendency that higher integration means more investment for suppliers. This trend shows differences in each single case. While the MAN Resende plant is completely owned by the OEM (land, buildings, machinery and equipment) the less integrated General Motors´ supplier park in Gravataí is outsourced most. Suppliers purchased their own piece of land and constructed their own separate factory building, equipped with its own machinery and equipment (Sako, 2006). The research of existing supplier integration models shows that shared investment and dedicated resources are to a considerable extend contingent. Although asset specificity increases while suppliers invest in there own manufacturing equipment. By contrast automotive supplier communities, which supply one OEM ore more OEM plants have reduced asset specificity to be flexible in fulfilling the needs of multiple customers. The use of less dedicated resources allows for a partial absorption of fixed costs while benefiting form logistics supplier integration (Reichhart and Holweg, 2008).

The closer suppliers are integrated the more important is the integration of IT systems. Proprietary or partly proprietary IT systems of the suppliers must be modified to fulfil the needs of the OEM. Entering the OEM site in the supply centre, condominium and modular consortium case does also mean to us OEM infrastructure. Therefore information flows and systems must be synchronised. IT integration enables the OEM and his suppliers to share logistics information like stock levels and production capacities in real time. This IT networking maintains the flow of materials in time to the rhythm of the production process. Central computers control a seamless communication between suppliers, logistics service providers and the car manufacturer.

Finally, transport costs, which have traditionally been mentioned as the main driver for supplier integration, play an important role. The closer the module supplier is based to the assembly line the shorter the transport distance and thus transport costs. Modules are generally bulkier with less pack density, therefore supplier proximity enables transport cost reductions. In the modular consortium case no transport system is needed at all, whilst automotive supplier communities use trucks to perform inbound logistics over a longer transport distance.

There are a lot of further criteria like product architecture, product variants, product value, volume and bulkiness, central supplier plant location, OEMs built-to-order strategies which will qualify for either high or low supplier integration (Reichhart and Holweg, 2008).

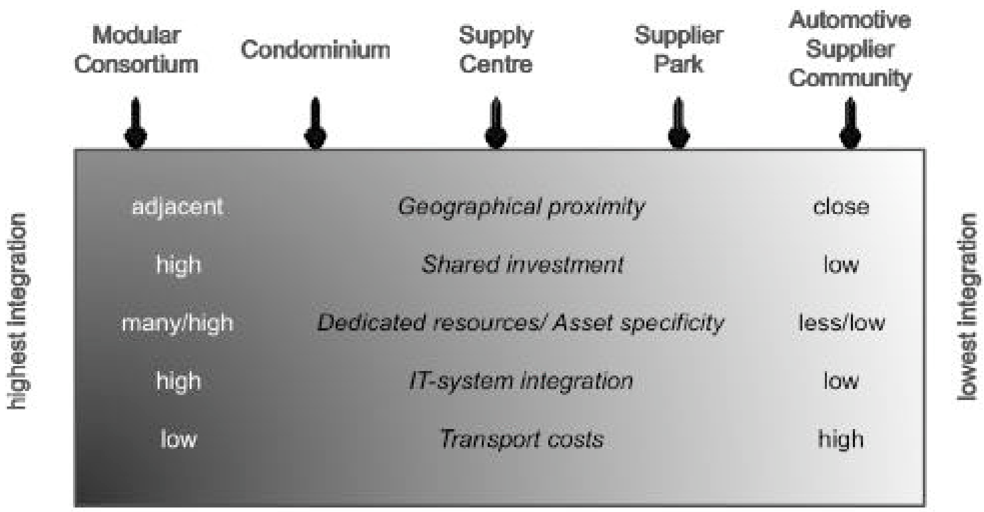

Figure 2: Comparison Logistics Conditions

National and Corporate Differences

Automotive supplier communities seem to be the exception rather than the rule. The BMW Wackersdorf example is based more on a political decision than on logistics needs. Whereas the Automotive Supplier Park in Rosslyn South Africa is linked to the long rang distance supplies. Consolidation of inbound material flows and the need to cooperate in competitive markets with a difficult local infrastructure were the main reasons for implementation.

The supplier park model is the most widely followed integration type in Western Europe, where these are commonly attached to brown-field sites. More recently, the Big Three have opened up supplier parks at some of their brown-field plants in the US. In 2004 Ford opened its first supplier park adjacent to the Chicago assembly plant. (Jürgens, 2003).

Skoda´s plant in Mladá Boleslav (Czech Republic) and Nissan´s European assembly plant in Sunderland (UK) had played an important pioneering role in in-house-supplier assembly (Jürgens, 2003). In both condominium cases availability of floor space adjacent to assembly line is the key criterion rather than national or corporate strategies. Historically grown assembly line structures and the implementation of lean principles to improve space utilisation determine the use of a condominium.

Modular consortium is most prominent to the opening of green-field plants. This approach has been pursued in some cases where new assembly plants were set up with suppliers operating part of the plant under their own responsibilities (Jürgens, 2003). The modular consortium example in Resende shows that totally new concepts with higher supplier integration are not possible in European and North American plants. Union resistance against outsourcing tasks to automotive suppliers has strong history in the US (e.g. the failure of GM´s Yellowstone project) and Europe (Reichhart and Holweg, 2008). In addition there is no ´Brazilian model´ because the MAN Resende, Ford Camaçari and GM Gravataí supplier integration examples in Brazil belong to the different integration types of modular consortium, condominium and supplier park (Sako, 2006).

In summary it can be said, therefore, that diversity in national and corporate configurations of supplier integrations models is very high, so that there is no clear trend to be seen.

Conclusions

While the research does not claim to provide a comprehensive survey of logistical supplier integration in automotive industry, it proposes a general categorisation that aims to provide a structure currently lacking further research into this phenomenon. A holistic and consistent understanding of different logistics integration types will be necessary which will allow for an explanation of morphological differences between these. Additionally, it will help in determining the actual number of integration types like supplier parks that exist in any region and support the academic study of integration models by providing consistent criteria for cross-site comparisons (Reichhart and Holweg, 2008).

Cross-company and inter-organisational supplier integration can only be understood with a holistic view of automotive supply chains. The increasingly improved supplier integration presented in this paper might also require the development of sophisticated measurement tools to assess the performance of the entire supply chain. The developed tool has to capture the state of integration and to quantify and evaluate in terms of synchronisation, bullwhip effect, pipeline inventory, cycle times, out-of-stock and backorder incidents.

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