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INTERNATIONAL PRODUCTION NETWORKS IN THE AUTOMOTIVE INDUSTRY: DRIVERS AND ENABLERS

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Abstract

The automotive industry was one of the earliest to internationalise, with overseas production by US companies already happening in the early 1900s. However, the arrangement for overseas automotive production at that time was quite different from the idea of international production networks in the contemporary sense. There were few linkages between international locations and overseas operations were designed either as largely self-sufficient, vertically integrated, replications of their domestic factories or as CKD/SKD assembly plants with little local technical content. By comparison, our current understanding of international production networks is that they are dispersed, collaborative, high value adding and centrally coordinated. This paper uses global company case analysis to identify the drivers and enablers that shape the international production networks of two automotive companies, BMW and Volvo Cars. The methodology contrasts with previous network studies of the automotive industry that have concentrated their analysis at the country and regional level.

Keywords: international production networks; automotive industry; case studies; drivers; enablers

1. INTRODUCTION AND AIM OF PAPER

The idea of establishing an international production network for automotive companies, in the sense that we understand today, is relatively very different from the concept of overseas production in the early 1900s when US manufacturers started to internationalise, or even the 1950s when European companies first established overseas plants. The US and European companies that were early movers did not have many linkages between their international locations and they designed their overseas operations either as largely self-sufficient, vertically integrated, replications of their domestic factories or as CKD/SKD assembly plants with little local technical content. By comparison, our current understanding of international production networks is that they have the characteristics of being “dispersed”, “collaborative”, “high value adding” and “centrally coordinated” rather than the more traditional “pipeline of physical transformation” [1]. The aim of this paper is to undertake an empirical exploration of the recent developments in international production networks within the automotive industry. Its focus is on larger (but not necessarily the largest) automotive companies. In particular, the paper investigates the most significant drivers and enablers that shape the way international production networks today have been designed, or have evolved. As evidence, it uses data from case studies of automotive companies in which the drivers and enablers for their international network design have been identified. One is BMW, which for its 3 brands has a network of 23 wholly owned and joint venture plants for parts production and car assembly, 5 “partner” plants for local assembly and 2 contract plants that provide additional capacity for producing more specialised vehicles. The other is Volvo Car Corporation, which for its single brand has an expanding international network including plants jointly operated with its Chinese owner Zhejiang Geely. Currently this owned network comprises 8 plants for parts production and car assembly, together with 3 centres for design, R&D and engineering. The paper addresses a research gap by considering the more contemporary approaches to international network design for production compared with earlier studies that have focused on more conceptual benefits of networks [2] and strategies underlying their configuration [3].

2. INTERNATIONAL PRODUCTION IN THE AUTOMOTIVE INDUSTRY

The automotive industry started to internationalise only a few years after the birth of the industry during the early 1900s. In 1910 General Motors established a joint venture in the UK and by 1930 had added car assembly plants in Sweden, Argentina, Brazil, South Africa, Australia, New Zealand, Japan, Indonesia, India and Spain. By 1929, Ford was assembling cars in the UK, Brazil, Argentina, Mexico, Sweden, Belgium, France, the Netherlands, Spain, Italy, Germany and Japan. Beyond the US, internationalisation of automotive companies was much slower. In the early 1900s the industry in Europe comprised a large number of smaller companies, so there was little motivation and insufficient resources for establishing foreign plants. Instead a number of European companies licensed production to newcomers elsewhere in the world. Large scale international production of European cars overseas did not start until after the Second World War, with Volkswagen establishing its plant in Brazil in 1953. In 1958 the British Austin Motor Company opened a plant in Australia and also during the 1950s the Standard Motor Company opened overseas plants in Australia, India, South Africa and France. By the 1960s and 1970s, internationalisation was becoming increasingly prevalent in the automotive industry as most of the main manufacturers started to open overseas plants. At the same time, new countries emerged as locations for automotive production and started to develop their own automotive industries. South Korea, and later China, became major automotive manufacturing countries with government strategy promoting the establishment of indigenous car and commercial vehicle companies.

3. DRIVERS AND ENABLERS IN OPERATIONS STRATEGY

Traditional operations strategy comprises the competitive priorities of the company (how it intends to position itself in the market related to the product and services offered), as well as decision categories (the decisions and capabilities that the company has to manage in order to comply with the competitive priorities). The different competitive priorities vary, but according to Wu and Ellis [4] the commonly accepted ones are quality, cost, lead time, delivery reliability, flexibility (which could include design flexibility and volume flexibility). Hayes and Wheelwright [5] also listed the decision categories for a factory manufacturing system, i.e.

- Capacity: amount, timing, type
- Facilities: size, location, specialisation
- Technology: equipment, automation, linkage
- Vertical integration: direction, extent, balance
- Workforce: skill level, wage policies, employment security
- Quality: defect prevention, monitoring, intervention
- Production planning/material control: sourcing policies, centralisation, decision rules
- Organisation structure: structure, control/reward system, role of staff groups

This list of priorities and decisions becomes even more complex when entering manufacturing networks acting globally.

4. EXTENDED OPERATIONS STRATEGY IN INTERNATIONAL NETWORKS

When applied to international production the competitive priorities and decision categories for factory level operations are also appropriate, but for the purpose of taking strategic network design decisions they will usually devolve down to second level drivers and enablers that are more relevant to the specific context of the company and its various network players (subsidiaries, partners, suppliers of materials and technology etc.). For example, the cost priority will normally have a longer time horizon and take account of the need to meet the demands of different geographical markets. And the decision category of vertical integration will be modified to take account of the dispersed nature of the network elements together with the way in which this impacts the conventional ideas about economies of scale.

In addition to the decision categories for factory manufacturing systems, Shi and Gregory [1] have identified other operations strategy aspects that are important to consider in international networks, i.e.

- Geographic dispersion: distributed factory condition
- Horizontal coordination: coordinated mechanism
- Vertical coordination: international dispersion of the corporate value-adding chains and their linkages
- Dynamic response mechanism: opportunity identify, and manufacturing mobility
- Product life cycle and knowledge transfer in international manufacturing networks
- Operational mechanism: network daily co-ordination, management information system
- Dynamic capability building and network evolution: learning by operations

Cheng et al [6] described the development of manufacturing networks and how the different plants within a manufacturing network are interrelated. What can be noted from their results is that the development of the plants is dependent on local knowledge, access to network knowledge, and how well top management succeeds in knowledge transfer/exchange to support development.

Karlsson and Sköld [7] added more organisational aspects on industrial networks and especially when the geographical distance is longer, as in international networks. In their study, they found that factories within a company group often compete with each other. None of the factories can be certain to get the task to produce, meaning that they need to be the best producer of that specific product. The choice is made based on different aspects, such as available capacity and competence, geographical suitability and availability of local suppliers, historical performance, and naturally also on cost performance. However, the factory that already has the task to industrialise a new product does, through its existing knowledge and capabilities, have a considerable advantage in this competition. The most important aspects of manufacturing networks and their interrelations are described in Figure 1.

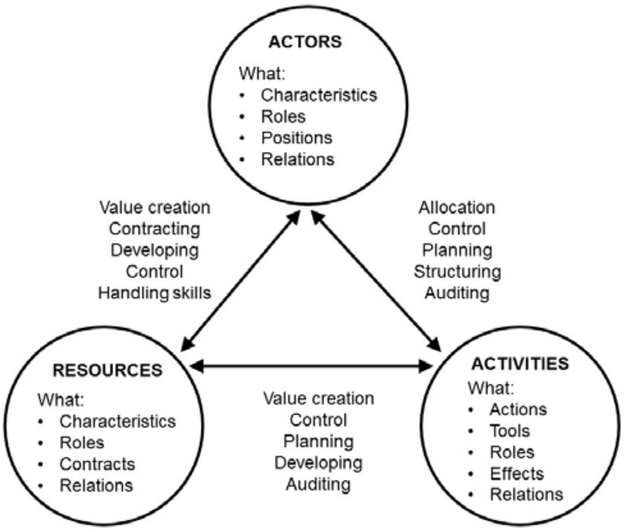

Figure 1: Manufacturing Network Context adapted from [7]

5. METHODOLOGY

For this paper two medium-size automotive companies have been selected, BMW and Volvo Car Corporation. In 2016 the three largest automotive companies (Volkswagen Group, Toyota and General Motors) each produced around 10 million cars. By comparison, in the same year BMW produced nearly 2.4 million cars and Volvo Car produced more than 530,000 (with its parent company, Geely, also producing more than 765,000 cars). Most of the data for the cases were collected from public sources including company reports, press statements and articles, published research, Internet sources etc. Both companies have also been the subject of related empirical research investigations by the authors over many years, so accumulated information from plant visits and interviews was used to supplement the data collected from desk research. Simple visual text analysis of the data was used to identify the main drivers and enablers that have shaped the configurations of each case company's international manufacturing network.

Of particular importance in the analysis was to construct a historical timeline that identified relevant acquisitions and disposals in order to ascertain the extent to which network design has been the consequence of new influences within the whole company group or legacy factors from past decisions. In using global company case analysis, the research approach contrasts with previous network studies of the automotive industry that have concentrated their analysis at the country and regional level [8], [9].

6. THE CASE COMPANIES

6.1 BMW company origins

BMW (Bayerische Motoren Werke) started in 1917 as an aircraft engine manufacturer based in Munich, Germany, but under the Versailles Treaty it had to stop producing military related products, so in 1922 began making small motorcycle engines and then complete motorcycles. Car production started in 1928 when BMW acquired the Eisenach car company and its facilities. The first model was a license built version of the British Austin Seven. During the 1930s BMW established a reputation as a maker of prestigious sports cars, then from 1939 to 1945 it built engines for the German air force and suspended car production. Between 1945 and 1951 some "BMW" branded cars were produced at the Eisenach plant, but this was in the Eastern Zone controlled by the Soviet Union so outside the jurisdiction of the West German authorities. Meanwhile the original BMW company produced motorcycles at its Munich plant until the dispute about its trade name was settled in 1952. By 1958 BMW was in financial difficulty and survived by making the Iso Isetta three-wheeled "bubble car". Only after 1959 was the company transformed by its new owners to become the international brand we know today. This transformation started with the introduction of BMW's New Class (Neue Klasse) cars during the 1960s.

6.2 Establishment of BMW's international plant network

In 1973 BMW's first overseas plant was established in South Africa to assemble complete cars for the local market from kits supplied from Germany. Then in 1979 it opened a dedicated engine plant in Steyr, Austria (250 km from Munich). By the mid-1990s BMW had 34 wholly-owned subsidiaries. Of these 14 were in Germany and the other 20 were located around the world. It also had more than 130 foreign sales operations. BMW's manufacturing activities were concentrated in six plants in Germany. These included a motorcycle plant in Berlin and a tooling plant in Eisenach (after German re-unification the old Eisenach car plant closed). In addition, BMW operated a number of overseas assembly plants in partnership with local companies. In Thailand, Indonesia, and Malaysia local partners assembled BMW cars from kits under joint venture manufacturing agreements. In 1994, three new overseas assembly plants were established. One was in the Philippines and another in Vietnam to assemble cars from kits supplied from Germany, thereby avoiding the high tariffs from which were exempt by being augmented with locally purchased components to comply with local content regulations. The third plant to be established in 1994 was in the USA. This comprehensive production facility at Spartanburg, South Carolina, has since proved to be one of the most important parts of BMW's international network, being dedicated to the production of several models for worldwide markets. In 1994 BMW also acquired the Rover Group in the UK, which was sold again in 2000. However, three significant parts were kept, the new Mini model, under development since 1995, a new engine plant and a body shop. In 1998, twenty-five years after opening its first overseas plant, BMW acquired the UK Rolls-Royce brand (but not the manufacturing facility for producing Rolls-Royce cars, which was acquired by Volkswagen along with the Bentley brand). BMW therefore entirely redesigned the Rolls-Royce models using major parts supplied from other BMW plants and built a new assembly facility in the UK.

6.3 Main features of BMW's international plant network

At the present time BMW has a network of 23 wholly owned and joint venture plants for car assembly and parts production, 5 "partner" plants for local assembly and 2 contract plants that provide additional capacity for producing more specialised vehicles. It also has 12 design and R&D plants in 5 countries. The number of BMW employees worldwide is 124,000. There are 8 plants in Germany, with 4 of these assembling cars and 4 focusing on parts and tooling production. Some of the assembly plants also produce parts including engines. One of the German plants that makes parts also assembles motorcycles. The plant in Austria is dedicated to making engines. Outside Germany there are car assembly plants in Brazil, India, the UK, the USA, Thailand (including motorcycle assembly), South Africa and Mexico (starting production in 2019). There are also joint venture plants assembling cars from kits in Russia, Egypt, Indonesia, Malaysia and Brazil (making motorcycles). In the UK, there are 2 assembly plants (Mini and Rolls Royce), a parts plant making body components and an engine plant. In China, automotive companies can only operate with a local partner so BMW has a joint venture with "Brilliance Automotive" and has 2 plants in Shenyang producing cars, various parts and engines. All cars made in China by BMW are for the Chinese market only but exports are being considered. Currently BMW and Brilliance do not share any production or parts supply. However, they have jointly developed electric cars with a separate Chinese brand. In Austria and the Netherlands two plants assemble special variants of the BMW Mini, but they are independently owned. BMW's wider international network includes 12,000 external suppliers in 70 countries. Of these, around 100 are first tier suppliers for major parts such as automatic transmissions, axles, steering columns, brakes etc. BMW has implemented the "supplier park" concept for its first-tier suppliers with the first being opened at its Leipzig assembly plant in 2005.

6.4 Volvo Car Corporation origins

The Volvo trademark was first registered in 1915 by SKF, the Swedish machinery bearing company based in the city of Gothenburg, with the name deriving from the Latin verb "volvere", meaning to roll. However, the company AB Volvo was not established until 1926 with the first car being produced in 1927 at a plant in Lundby, near to Gothenburg. During the following 70 years Volvo grew to become a large international group making cars, buses, trucks, construction equipment, marine engines, aircraft engines and various ancillary products. Cars produced by Volvo gained a reputation for quality, reliability and durability, which enabled the company to build on key markets in Europe, North America and worldwide. By 1974 Volvo had four car assembly plants in Sweden and several other plants producing automotive parts. In 1999 Ford Motor Company bought AB Volvo's car division, Volvo Car Corporation (Volvo Personvagnar) and it became part of Ford's Premier Automotive Group together with the existing brand of Lincoln and its other European acquisitions of Jaguar, Land Rover and Aston Martin. During the next 10 years Ford tried to build its stable of distinctive prestige brands and also sought to gain economies of scale through the use of common designs, parts and group purchasing. However, Ford's strategy failed and drained both cash and resources at the time of the economic downturn. In 2010 Volvo Car was therefore sold to the Chinese automotive company, Zhejiang Geely Holding Group. Under Geely, Volvo Car started a new phase of its development focusing on an expansion of sales and manufacturing in China and the Asian region as well as re-establishing its reputation and building on existing markets.

6.5 Establishment of Volvo Car's international plant network

In 1963 Volvo Car Corporation opened its first overseas plant in Halifax, Nova Scotia, Canada. The purpose was to circumvent North American import tariffs on foreign goods and to capitalize on the newly signed Canadian/American Auto Pact. Then in 1965, the Ghent plant in Belgium was opened Also during the 1960s the Malaysian government offered incentives to foreign automotive companies in the form of lower duties on vehicles that were assembled locally from 'kits' of parts sent from parent factories. Therefore, a joint venture was formed in 1967 between Volvo and Federal Auto Holdings for assembly of cars at a new plant in Shah Alam near Kuala Lumpur. In 1972 Volvo bought the Dutch company DAF and for several years produced cars at the plant in Born. The last Volvo was produced at Born in 2004, although by that time the plant had been sold to Mitsubishi Motors. In 1998 the Halifax plant was closed, just before the acquisition of Volvo Car by Ford. In 2006 Ford started to produce Volvos in Chongqing, China, at its joint venture factory called Chang'an Ford Mazda Automotive. Since 2010, under the ownership of Geely, several new Volvo assembly plants have been established in China, although production under contract continued at the Ford joint venture plant in Chongqing until 2016.

6.6 Main features of Volvo Car's international plant network

At the present time Volvo Car Corporation has 10 plants for car assembly and parts production, together with 4 centres for design, R&D and engineering. The number of Volvo Car employees worldwide is 31,000. There are 3 plants in Sweden with one of these assembling cars and 2 focusing on parts production. The single Swedish assembly plant, at Torslanda near Gothenburg, has recently been expanded to increase capacity from 200,000 to 300,000 cars per year. The last of the other car assembly plants in Sweden was closed in 2013 and another parts-producing plant was sold to an independent supplier in 2015 since only 30% of its output was for Volvo Car. The plant in Belgium is the company's second in Europe and has a capacity of 270,000 cars per year. A new plant in the USA (in Charleston, South Carolina) is due to start production in 2018 with initial capacity of 100,000 cars per year. Design and R&D activity for Volvo's cars is carried out in a number of centres including Gothenburg, California and Copenhagen in Denmark. In China, Volvo Car has a joint venture with Geely (its owner). Since Geely's acquisition of the Volvo two new car assembly plants have been built, at Chengdu in Sichuan Province and Daqing in Heilongjiang Province. Also, one other plant is under construction at Luqiao in Zhejiang Province. In addition, there is an engine plant at Zhangjiakou in Hebei Province and an engineering and R&D centre in Shanghai. All cars made in China by Volvo are for the Chinese market only but exports are proposed in the future. Volvo plans to make around 800,000 cars per year globally by 2020, with one third produced in China. Currently, Volvo Car and Geely do not share any production or parts supply. However, they have a technical collaboration for electric vehicles and it is also proposed to make a new small SUV both in Belgium and at the plant in Luqiao. Using common architecture there will be a Volvo model of this car and a Geely version sold under a new brand name. The wider international network of Volvo Car Corporation includes more than 4,000 external suppliers. Of these, 600 are described as "business partners delivering production materials for serial production". In 1995 Volvo Car opened a supplier park for its plant in Belgium and in 1998 a supplier park was opened in Gothenburg after halving the number of the plant's first tier suppliers to 150, of which fifteen located into a new supplier park producing modules for headliners, seats, tailgates, bumpers etc.

7. CASE ANALYSIS

A detailed analysis of the drivers and enablers that have influenced the design of BMW's and Volvo's international production networks has revealed a number of themes that are common to both companies and other aspects that are unique to their particular situation. Factors that have determined a unique approach include markets, ownership and legacies from acquisitions and disposals.

7.1 Drivers

The drivers can be grouped according to a number of broad themes, i.e. environmental and safety standards (for passengers and pedestrians), flexibility and agility, leanness, ownership imperatives, legacies from mergers and acquisitions, technology security, currency exchange movements, and cross-border obstacles resulting from trade restrictions. Table 1 provides a summary of the main themes together with examples of associated key features at Volvo Car and BMW. It also highlights the principal factors that require consideration when designing or reconfiguring international production networks. Three key features have been identified under the environmental and safety standards theme. The first two of these relate to emissions control and efficiency of motor vehicle power units.

Both Volvo Car and BMW have developed internal combustion engines powered with biofuels, although with subtle differences. Volvo's main focus has been on the Swedish and European E85 (85% ethanol) standard, whereas BMW has focused mainly on the Latin American Flexfuel E100 standard that is prevalent in Brazil with its warmer climate. In this situation ethanol, made from local sugar cane, is a more feasible engine fuel when either used in its pure (100%) form or mixed with any amount of petroleum. With this aspect, markets and R&D centres are the principal factors to be considered. Under the same environmental theme both companies have also been developing alternative forms of propulsion, although to date Volvo been following mainly the hybrid engine route (with 20% of its X90 crossover model being hybrids),

Table 1: Drivers and network design factors

Theme of drivers	Volvo Car key features	BMW key features	Network design factors
Environment / safety	E85 biofuel engines for Sweden and European markets	Flexfuel E100 engines for Latin American markets (Brazil)	Markets; R&D centres
	Hybrid vehicles	Electric vehicles	Markets; Supply chain
	Passive crash protection and collision avoidance	Focus on active safety features	Markets; Technology partners
Flexibility / agility	Scalable Product Architecture (SPA)	Mixed model assembly plants	Supply chain
Leanness	Limited options offered	Build to Order	Markets; Suppliers (supplier parks)
Ownership	Various changes in ownership	No ownership change (acquisitions only)	Owner influence
Legacies from mergers and acquisitions	Legacy of Volvo Group and Ford	Legacies from Rover	Plants; Suppliers
Technology security	Transfer risks through ownership and possible competing brands	Transfer risk through partnership requiring control of IPR	Nature of partnerships; Workforce mobility
Currency exchange	Expanding outside Europe but exposure to CNY risk	Multiple locations to minimise exchange rate risk	Dispersed networks
Cross border obstacles	Mainly limited to EU trade agreements	Production in EU, NAFTA, Mercosur and ASEAN	Tariff restrictions; non-tariff barriers

whereas BMW has placed more attention on the development of electric vehicles (with the BMW i3 becoming the best-selling electric car in Europe during 2016). With this aspect, the principal network design factors are markets and supply chains for engines and transmissions. Also within this theme there are some differences in the way the two automotive companies have addressed the question of passenger and pedestrian safety. Volvo Car has traditionally focused on passive crash protection and more recently on collision avoidance in accordance with its well-known market strategy of making safety a priority. BMW on the other hand has a market strategy based on driving performance, which is reflected in its focus on building active safety features into its cars. With this aspect, markets and technology partners are the principal network design factors. Compared with more traditional factory level priorities the flexibility and agility theme within the international production networks of both companies focuses mainly on design rather than volume flexibility. Volvo Car has recently developed a concept known as Scalable Product Architecture (SPA) to enable greater model range and variety based on common modules. BMW on the other hand has placed its focus on mixed model production systems at its international plants to enable a wide range of offerings in local markets. This aspect places greatest emphasis on the supply chain and its capability as the principal network design factor. Since the early 1990s lean production concepts have become well embedded in most automotive companies. However, at Volvo Car and BMW there are some differences in implementation that impact on international network design. These partly result from the relative market size and sales strategy of each company. Volvo Car offers a comparatively limited range of options for its models and provides a large number of features as standard, thereby enabling leanness in a system for building to stock. BMW on the other hand has developed a build-to-order system, which to enable lean production means having greater coordination within the supply chain. For both companies this aspect places markets, suppliers (and supplier parks) at the centre of their network design thinking. The theme of ownership, together with legacies from mergers and acquisitions, has a profound impact on international production networks. In some respects, this aspect is outside the control of network designers, although in other cases an acquiring firm may be influenced by the existing network of an acquisition target. The situation of Volvo Car has mainly been as an acquired company, with its past acquisition of DAF being made by the Volvo Group and having only short-term impact on its car division. Nevertheless, its acquirers (Ford, and more recently Geely) have still imposed considerable influence on how its networks have evolved. By contrast, BMW has made a small number of important acquisitions that have influenced both its model range and also the network of production facilities used to support all its manufacturing activities (at its own plants and also its suppliers).

The last three themes in Table 1 are all consequent on cross border considerations and the impact they have on international production networks. Technology security is of particular concern for retaining competitive advantage and both companies are exposed to risk through their international ownership structure and partnerships. Workforce mobility into and out of the international network is also an important design factor within this aspect, so requires careful management control. Currency exchange represents another theme with both opportunities and risks. Due to its larger size, BMW has been able to manage this aspect more effectively by operating in multiple locations, with its plants in the USA and Latin America being operated partly as a measure to hedge against currency variations as well as providing greater cost security when selling to local markets. Outside Sweden, Volvo Car by contrast has traditionally focused production and sales within Europe and more recently the “Eurozone” common European currency area, although the more recent expansion of its network into China has created some currency risk regarding the Chinese Renminbi Yuan (CNY). Only in 2015 did it start construction of a new manufacturing plant in North America after closing the Canadian facility almost 20 years previously. The final theme in Table 1 relates mainly to financial tariffs and other cross border non-tariff barriers such as country product standards and cabotage restrictions. The move towards free trade agreements and single markets has provided some mitigation with Volvo Car traditionally benefiting mainly from the EU single market and to a lesser extent the South East Asian (ASEAN) free trade agreement, while BMW has also more recently taken advantage of the free trade agreements in North America (NAFTA) and Latin America (Mercosur) as well as ASEAN.

7.2 Enablers

To enable smooth operations of their international production networks, both companies make extensive use of ICT solutions for information sharing and control. BMW has developed a "Partner Portal" as its interface and communication platform for the whole BMW group and its various partners. It also has a "Business Network Portal" for employees and partners to access the company's business services and electronic mail systems. The equivalent Volvo Cars "Supplier Portal" provides information and communications for suppliers regarding purchasing conditions, payment procedures, quality and sustainability. Supply of parts to the international production network is also simplified by reducing the number of first tier suppliers and making extensive use of product modules. Both BMW and Volvo Car have internal component manufacturing facilities or dedicated third party delivery of complete sub-assemblies from supplier parks (such as cockpit and dashboard modules, seating units, automatic transmissions etc.). Their role is important to network design and control. Of similar importance is the role of specialised shippers and providers of third party logistics solutions for materials. For its plant in Brazil the port of Paranaguá is uniquely equipped for handing specialised RoRo vehicle carriers with movable decks, while similarly the port of Gent has been upgraded and equipped for shipping the Belgian production of Volvo Cars. Efficient technology transfer from the parent company to subsidiaries and partners has become a vital aspect of international production networks and, as mentioned earlier, technology security has become an important consideration for this enabler. In the same way, international skills mobility is an enabler but carries risk of knowledge misappropriation as personnel move within networks, and especially when interacting outside the network.

8. DISCUSSION

The purpose of this empirical study has been to explore recent developments in international production networks with a view to identifying and assessing the main drivers and enablers in two medium size automotive companies that both target the same customer segment, i.e. the premium market. It finds that network design has moved beyond the traditional "keiretsu" supply arrangements of Japanese automotive companies, which were typically associated with the lean production concept represent in an earlier, narrower model of manufacturing networks. These early types of plant arrangements proved incapable of achieving the need for speed of change, flexibility and cost cutting that was demanded from the late 1990s and were also more suited to plant networks that were largely distributed domestically rather than internationally [10], [11].

9. CONCLUSION

The current study has found that the principal imperatives of cost reduction and quality improvement are now achieved mainly through actions within the company's own network elements rather than externally through pressure on the supplier network. Among the drivers that have been identified for networks today are several that are less closely related to the priorities of quality, cost, lead time, delivery reliability, and volume flexibility, which are now regarded as norms, so therefore taken as read, and thus implicitly built-in as essential attributes of the core network structure, while newer priorities drive the design of more contemporary networks.

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