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The role of suppliers in enabling differing innovation strategies of competing multinationals from emerging and advanced economies: German and Chinese automotive firms compared

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ABSTRACT

This paper examines how different supplier relationships enable multinationals from emerging and advanced economies to pursue different product innovation strategies and the implications for international research and development (R&D) configuration and competition in mid-market automobiles. We use a pair-wise comparison of case research on German and Chinese firms, including two assembly groups (Volkswagen and SAIC) and two tier-1 suppliers (Bosch and Hasco). We find that the German firms adopt a closely integrated and in-house driven approach to vehicle development enabled by close, two-interaction with suppliers over a long cycle. The Chinese firms, by contrast, base their development largely on assembling externally available technologies drawn from around the world to create products that are improved through rapid design iterations drawing on market feedback. This is enabled by a different relationship with suppliers that involves providing innovation embodied in modular components and sub-assemblies to Chinese vehicle makers. Exploring the implications for existing theory we conclude that: (1) different supplier relationships play an important role in enabling competitors from advanced and emerging economies to adopt different innovation processes; and (2) these differences in nature of the innovation process need to be explicitly incorporated into models explaining the international configuration of R&D. The role of local R&D centres is not necessarily to internalize local knowledge. Instead, it may be to facilitate the integration of knowledge provided by local suppliers, necessitating the nature and role of absorptive capacity to be re-thought. Finally, we explore the implications for future competition in the global automobile industry, limitations and future research avenues.

1. Introduction

Over the past two decades the Chinese automotive industry has grown at a staggering pace. Since 2013, China has overtaken the US to become the largest automotive market in the world, while maintaining its growth trajectory. The rapid growth in domestic production capacity was underpinned both by the investments of foreign multinationals from the advanced multinational economies (AMNEs) as well as the creation of indigenous Chinese car producers. Leveraging the growth of its domestic market, China aimed to establish her own 'national champions' and ultimately Chinese emerging market multinationals (EMNEs) through explicit policy intervention (Nolan, 2001; Sutherland, 2003; Thun, 2006). However, leading global firms have also deeply penetrated the Chinese market to compete with the domestic entrants, localizing most of their entire value chains in China.

Although AMNEs and Chinese EMNEs operate side by side in China, there is growing evidence both anecdotal and from empirical studies that each of these groups of firms make very different strategic choices about how they innovate. Awate et al. (2015), for example, found that AMNEs tend to internationalize their research and development (R&D) activities to source local market knowledge, while EMNEs internationalize their R&D activities to explore external knowledge, and feed it back into the product development process. The role of suppliers in enabling these different innovation strategies and the resulting implications for the local R&D activities of vehicle makers, however, is incompletely understood. In this paper, we focus on how the willingness of suppliers to adjust their roles underpins the viability of the different innovation strategies pursued by AMNEs versus EMNEs. We also show how, because of these different supplier roles, AMNEs and EMNEs can configure their R&D differently and to set different objectives for their local R&D subsidiaries. This, in turn, has implications for the absorptive capacity EMNEs require to successfully pursue innovation that is competitively relevant.

Until recently, these differences had little impact on competition

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because the Chinese automotive market, along with many other emerging markets, was strongly divided into two segments: the premium segment of expensive, technologically sophisticated and highly appointed cars, and the lower segment of affordable, but relatively functional, vehicles (Brandt and Thun, 2010). The premium segment was occupied by AMNEs (sometimes in partnership with local companies) while the indigenous Chinese firms occupied the lower segment and so competed primarily against other Chinese assembly groups. With the introduction of affordable sport utility vehicles (SUVs) and the increasing sophistication of Chinese automotive consumers, however, demand has shifted significantly, opening up a large and under-served mid-market segment. In response, both AMNEs and Chinese EMNEs are now trying to enter that mid-segment, resulting in a 'fight for the middle' so that for the first time, Chinese automotive firms are directly competing with their AMNE cousins in China.

Faced with this new competitive landscape, AMNEs have attempted to lower their costs by localizing some of their R&D activities in China. In parallel, Chinese firms have been developing their R&D and supplier networks both domestically and internationally. At the same time, R&D processes have undergone deep structural changes, as firms have restructured their global activities during the 'global business revolution' (Nolan, 2001; Nolan et al., 2007). During this restructuring phase, most firms have fine-sliced their value chains (Kaplinsky, 2004; OECD, 2013; WTO, 2013), outsourced many of their activities previously done inhouse (Chandler, 1977; Milberg and Winkler, 2013), and restructured to focus on their 'core business' (Chandler, 1994; Ruigrok and van Tulder, 1995). In addition to outsourcing some of their administrative and production activities, they have also begun to outsource some of their R&D (Contractor et al., 2010; Bertrand and Mol, 2013). This is especially true for sub-components and modules, where the responsibility for future innovations has been handed over to the suppliers (Nolan et al., 2007). This has led to more intimate assembly–supplier relationships (Humphrey and Memedovic, 2003; Birkinshaw and Fey, 2005; Gereffi et al., 2005; Frederick and Gereffi, 2009), and new forms of 'project network organizations' for innovation and development (Manning, 2017). These developments have converged, resulting in fundamental changes in the R&D value chain of the industry and also altering the role suppliers are called upon to play in innovation and product development.

The fact that suppliers have been willing to adjust their roles depending on the different innovation and competitive strategies of AMNE and EMNE vehicle makers has enabled a divergence between these groups. This divergence is of growing interest for two reasons. First, because AMNEs and EMNEs are competing head-to-head in the Chinese market. Second, because the divergence in innovation strategies opens up the possibility of disruption of established players (in the sense of Christensen, 2006). Beginning with the Chinese market, this may have far-reaching implications for future competition in global automotive industry.

To better understand these ongoing changes in the automotive industry and the role of suppliers in enabling them, we focus on the following research questions:

RQ1: How have suppliers enabled EMNEs and AMNEs to pursue divergent innovation strategies?
RQ2: What are the implications of this supplier-enabled divergence in innovation strategies for differences in the international R&D configurations of EMNEs and AMNEs and, in particular, the absorptive capacity required to be competitive?
RQ3: What are the implications of these different supplier roles and innovation strategies for the competition between AMNEs and EMNEs in different market segments?

In investigating these questions, we start by describing the paired sample of AMNEs and Chinese EMNEs for which we collected case study data on and the role of suppliers in their product development processes and the configuration of their international R&D activities. We then explain our research methodology. We then detail the differences we observed between choices made by the AMNEs and Chinese EMNEs in our sample. Having characterized these key differences, we then examine how well theories drawn from the extant literature explain the reasons for the differences we observe. This analysis leads us to propose a number of extensions to existing theory that might better explain our results. Finally, we explore the potential implications for future competition between AMNEs and EMNEs, concluding with some limitations of the study and suggestions for future research.

2. Research methods

For the purposes of this study, an inductive approach seemed most appropriate, to explore the relatively new phenomenon of supply-based integration in the R&D process (Gibbert et al., 2008). We designed the study to include multiple case studies, because multiple cases 'yield more robust, generalizable' findings than single case studies (Eisenhardt and Graebner, 2007). Using multiple case studies also enhances external validity and provides a good basis for analytically generalizable findings (Eisenhardt, 1989; Gibbert et al., 2008).

2.1. Sample selection and industry context

We limited our sample selection to a single industry, to gain comparable results for a better understanding of the different product development processes. The automotive industry gave rise to the concepts of Fordism and lean production and is an influential trend-setting industry (Womack et al., 1990). The global auto industry epitomizes modern networked business relations as orchestrated by multinational enterprises (MNEs) (Dicken, 2010; Hertenstein et al., 2017). It may therefore provide insights into how supply firms are involved in the product development processes within these business networks and the resulting implications for EMNEs' R&D configurations. The structure of business networks differ somewhat from industry to industry. In the automotive industry, product development is of a highly "integral nature, leading to thick 'relational' linkages between lead firms and first-tier suppliers" (Van Biesenbroeck and Sturgeon, 2010: 209). Insights gleaned from the automotive industry may therefore be relevant to other industries, particularly in manufacturing, that involve complex supply chains entailing numerous discrete inputs.

To analyse the R&D configuration of an EMNE and AMNE, we selected two case studies for a pair-wise comparison: one assembly firm from China, and one from Germany. For triangulation purposes, and to gain insights from multiple vantage points of the firms involved in the R&D process, we selected two large tier-1 supply firms that are deeply involved in the original equipment manufacturers') (OEMs') vehicle development process as additional supporting case studies (Jick, 1979; Gibbert et al., 2008). Including these suppliers promises deeper insights and additional information regarding the R&D and simultaneous engineering process for vehicles. We further selected a number of additional supply firms to cross-validate information and thereby increase generalizability and enhance internal validity (Gibbert et al., 2008). The firms were selected to increase heterogeneity by including technology service providers involved in the vehicle development process (Ricardo and MBtech), additional large systems suppliers (Continental) as well as component suppliers (Marquardt) involved in development process (see Table 2).

We selected China as an emerging economy because China has pursued policies designed to encourage its own indigenous "national champions" in this strategically important industry (Sutherland, 2001; Thun, 2006). Germany was chosen for its leading position in the global automotive industry, with three of the largest ten assembly firms (BMW, Daimler and Volkswagen) and the largest suppliers coming from Germany (BOSCH and Continental). Table 1 provides an overview of our case-study sample.

Table 1
Overview of case studies.

Firm	Case Information
Volkswagen **Revenue:** 222 bn US$ **No of R&D locations:** 7 **Products:** Passenger cars, busses, motorbikes, commercial vehicles	The Volkswagen Group is one of the three largest automotive assemblers in the world (together with Toyota and General Motors), with over 10 million vehicles sold in 2014 and an annual revenue of over 200 bn US$ and 570,000 employees in over 100 production facilities across 27 countries. With an annual R&D budget exceeding US$5bn, Volkswagen is one of the world's most innovative and technologically advanced automotive assembler, with deep knowledge and capabilities on a breadth of technologies in the automotive industry, including powertrains, chassis development, powertrain integration, driver comfort, safety and driving experience.
SAIC **Revenue:** 101.7 bn US$ **No of R&D locations:** 3 **Products:** Passenger cars, busses	Shanghai Motor Corporation (SAIC; from its former name Shanghai Automotive Industry Corporation) is one of the "big four" state-owned car assemblers of China together with FAW, Dongfeng and Chang'an. With a total output of 5.6 million vehicles in 2014, a revenue of 101.7 bn US$, and almost 145,000 employees, SAIC is the largest Chinese automotive assembler. SAIC has two large joint ventures, one with Volkswagen (since 1984) and one with General Motors (since 1997), and produces own passenger cars under its Maxus, Roewe and MG Motor brand.
BOSCH **Revenue:** 55 bn US$ **No of R&D locations:** 13 **Products:** Injection systems; steering systems; ABS; breaking systems; ESP; engine control systems	The Robert Bosch GmbH is a producer of white goods, industrial goods and automotive components. Its automotive unit is the world's largest automotive supplier in terms of revenue (at 55 bn US$). It offers products such as injection systems, steering systems, ABS, braking systems, ESP and engine control systems. Founded in 1886, the company today employs over 290,000 employees in more than 350 locations across 150 nations, and serves all large assembly groups worldwide.
HASCO **Revenue:** 8.4 bn US$ **No of R&D locations:** 8 **Products:** Interior & exterior trimming, metal forming & dies, function parts, electric parts	Huayu Automotive Systems Co., Ltd. (HASCO) is a publicly traded automotive component manufacturer, that was spun out of SAIC in 2009 and is still majority owned by SAIC Motor (60.1%). With annual revenue of 8.4 bn US$, HASCO is China's largest domestic automotive supplier. HASCO has 28 directly invested companies with over 160 manufacturing plants. Among HASCO's subsidiaries, two stand out as the most advanced in terms of R&D capability, internationalization, and scale: Yanfeng and YAPP. Yanfeng is a company produces a range of product for interior and exterior trim, metal forming equipment and dies, mechanical parts and electric components; YAPP is a producer of plastic fuel tanks.

The assembly firms for the case studies were selected based on the following criteria: the firms should focus on passenger cars and be a volume producer with a leading market position in their respective home market. Additionally, accessibility played a role for the Chinese assembly firm. Other potential firms such as Dongfeng, FAW, Chang'an or BAIC with close ties to conservative provincial governments proved more difficult to gain access to.

Similarly, the two main supply firms were selected based on their size and position in the market, position in the value chain (as systems integrators) and with close ties to the respective assembly firms. The German firm, BOSCH, is currently the largest automotive supply firm in the world. The Chinese counterpart, HASCO, is the largest Chinese automotive supplier. Both companies are manufacturers of components and sub-systems, and both have close ties to one or both of the two assembly firms Volkswagen and SAIC.

2.2. Data collection and analysis

Each case study is based on several data sources like interviews, observations and archival data for triangulation purposes (Jick, 1979). Additional secondary data was collected from annual reports, company web pages, magazine and newspaper articles, published interviews by company officials or books on the Chinese automotive industry, to increase validity (Yin, 2003; Eisenhardt and Graebner, 2007; Gibbert et al., 2008). The interviews were semi-structured, and questions evolved during the progress of the data collection (Saunders et al., 2007; Kvale and Brinkmann, 2009). To avoid retrospective sense-making, interview partners were chosen from different functional areas such as procurement and R&D departments, different hierarchical levels, including board members, senior managers and engineers, and from different geographical locations (Germany and China) of the companies (Eisenhardt and Graebner, 2007). Interviews with project managers involved in day-to-day R&D helped to get deep insights into the R&D processes at the firms, combined with high-level strategic views from senior managers and board members.

A total of 42 interviews were conducted. We started with a pilot phase with Volkswagen that focused on gaining a deep understanding of the R&D process in the industry, to shape the questions. Subsequently, we conducted two rounds of interviews with each case. In the first round, we asked basic questions until a coherent picture emerged. The second round complemented the first by clarifying issues and asking follow-up questions that were developed from the initial findings. Most interviews lasted between 30 and 90 min. All interviews were conducted between July 2012 and May 2015. As a result, data collection ended before the Volkswagen emissions scandal erupted (although we do comment on how the scandal fits the patterns we observed).

Each interview began with background questions about the interviewee, their experience in the industry and their role in the firm. This was followed by the semi-structured interview, in which we asked open questions regarding the R&D configuration of the firm, R&D processes and collaborations with other firms. We encouraged interviewees to provide more details when their descriptions were brief and when novel strands of narrative emerged (Strauss and Corbin, 1990; Martin and Eisenhardt, 2010). Data collection stopped when theoretical saturation was reached (Strauss, 1987).

The data was coded using an open coding system and thematically organized around common themes that emerged from the interviews (Saunders et al., 2007; Kvale and Brinkmann, 2009). We started the data analysis by identifying relevant issues and repeating topics from the interviews (Yin, 2003). We used within-case and cross-case analyses, using replication logic from the cases (Eisenhardt, 1989; Miles and Hubermann, 1994).

3. Case study findings

In line with our research questions we first compare and contrast the role of the supply firms in the vehicle development process of the two assembly firms, Volkswagen and SAIC, triangulating these findings using interview data from both the assemblers and their suppliers. We then compare the international R&D configuration of the four companies in our sample.

3.1. The differing role of suppliers in innovation and product development in Volkswagen and SAIC

Vehicle development is a lengthy and elaborate process. The process typically takes 48 months for AMNEs, from "concept initiation" to "start of production" (Fig. 1), excluding the pre-decision process at a strategic level that includes design studies, market research and technology

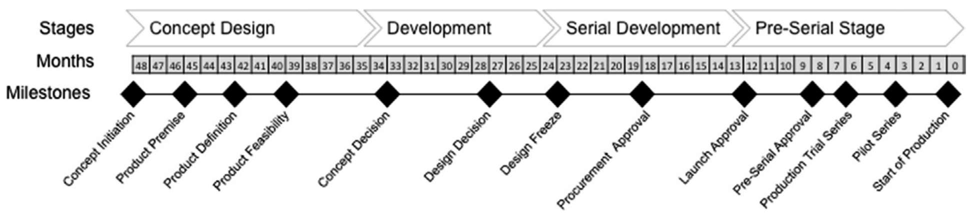

Fig. 1. The vehicle development process.

scouting to lay out details and validates the concept. Since the majority of engineering and R&D occurs after "concept initiation", we began our analysis from this milestone.

The vehicle development process can be broadly grouped into four phases: concept design, development, serial development and pre-serial stage. The *concept design* phase includes the conceptualization of the vehicle, its features, target performance, configurations of modules such as engines, gearboxes, entertainment systems etc., as well as development-, production- and market feasibility. During the *development* stage, the actual components and modules are developed and designed, simulated, prototypes produced and thoroughly tested. The "design freeze" milestone marks the end of this process, at which point all components are fully defined and designed. What follows is the *serial development* stage, during which the readily defined components are tested for mass production and adapted to meet serial production quality. Any design faults are eliminated, and tooling and production lines are defined for mass production. The serial development phase marks the end of the development, and the *pre-serial [production] stage* ramps-up the volume production in the designated production lines.

Supply firms play an important role throughout the product development process. All customized components and modules that go into the final product have to be designed, developed, tested and integrated into the system before the design freeze milestone. Suppliers with specialized capabilities and knowledge underpinning important components are involved in the process from day one.

3.1.1. Volkswagen's approach to integrating supply firms in vehicle development

Volkswagen has a very high level of in-house R&D capability, with a deep vertical integration, ranging from power-train to interior design. (Interview, Volkswagen 060712). Despite Volkswagen's relatively integrated R&D, suppliers play a key role in innovation and development within the vehicle development of Volkswagen. Large suppliers such as BOSCH or Continental are deeply involved in the development of vehicles. For instance, Volkswagen's internally developed and manufactured engine models require the technology and knowhow of the leading injection system suppliers BOSCH, Continental, Delphi or Denso, or engine cooling systems from Mahle. With the introduction of stricter emissions standards worldwide, core supply firms play a key role in the continuous development of more efficient engines and vehicles. Only with the expertise of external supply firms is Volkswagen able to meet the emissions standards and ensure performance and quality.[1] Superior performance is achieved through expert system integration and many rounds of testing and fine-tuning of a multitude of interconnected components and modules, such as chassis components like suspensions, engine components like cooling systems, exhaust systems, injection systems and interfaces to gearbox and the extended powertrain. Supply firms like Ricardo, a service provider for combustion engine and powertrain technology that developed famous engines like the 1000 horsepower, 16 cylinder engine for the Bugatti Veyron (a Volkswagen Group vehicle), or engine components and module manufacturers like BOSCH, Continental, Denso, Delphi and Volkswagen, all work together in what Volkswagen calls the "simultaneous engineering process": "We are very proud of our simultaneous engineering process. For complex components, we bring together teams from ten or more different supply firms, each of which has an expertise in one particular area … It is crucial to bring everyone involved to the table on a regular basis. We really need to develop all at the same pace, because even a tiny change in one component can interfere with the performance of another. It would make no sense if one supplier develops its component to perfection, only to realize it undermined the performance of another, thereby compromising the entire system performance … Sometimes, during hot phases, we meet weekly to discuss progress and change." (Interview, Volkswagen 030912). It is important to note that Volkswagen has extensive in-house knowledge of the development process for all components and modules enabling it to integrate these into a "finely tuned" system that results in a high-performance vehicle. Therefore, Volkswagen develops close relations to the "developer suppliers", and brings numerous supply firms together for a simultaneous collaborative development. The process includes collaborative research, design and testing of several components, for which different supply firms are responsible. Such a process requires key knowledge at the assembly firm, trust between the collaborating firms and managerial capabilities to orchestrate complex systems development.

This elaborate process, apt for the mainstream segment of mature markets, however, risks creating vehicles that are over-engineered compared with the requirements of the mid-market in China. For years Volkswagen has tried to develop a budget car for the emerging markets (especially China) but has continuously failed to do so, largely because its engineers have proved unwilling to lower the specifications to develop a "good enough" vehicle with a combination of performance and price attractive to the mainstream Chinese market. Even though consumer demand and regulatory frameworks allow lower specification for components such as chassis parts, engine duration tests, etc. Volkswagen engineers bristle against developing such a vehicle: "Because of our high standards, our processes, but also the mindset of our engineers, we are simply not able to create low-cost vehicles with our platform system. Every component is customized and part of our MQB system [which stands for "Modularer Querbaukasten", the transversal vehicle platform], so that it can be used in different vehicles. It therefore has to meet our minimum internal requirements, which makes it very difficult to lower cost." (Interview, Volkswagen 130215)

3.1.2. SAIC's approach to integrating supply firms in vehicle development

Compared with Volkswagen, SAIC has shallower knowledge and capabilities in the breadth of automotive-related technologies and products. Because of its joint venture with Volkswagen, SAIC is familiar with Volkswagen's supply base and uses the same firms for many of the core components in its own vehicles. For instance, BOSCH is also the main supplier of injection systems for SAIC's engines. And like Volkswagen, SAIC relies on some of the suppliers' development and innovation capabilities, while supply firms for simple mechanical components are *produce per blueprint* suppliers. Yet, the role of the *developing* and *innovating* suppliers is very different to its role in Volkswagen's development process.

The fact that SAIC's overall vehicle development capabilities are much shallower influences the approach to systems integration and the role of supply firm in the process. Rather than a fine-tuned

[1] Although, as the subsequent "defeat software" scandal demonstrated, even drawing on available external expertise appeared to be insufficient to reach the performance standards regulators had set without a loss of vehicle performance.

simultaneous engineering process, involving several supply firms to develop new components to meet the high-performance expectations, SAIC draws on the expertise and existing technologies and component configurations readily available from the supply firms. “We don’t have such large development teams, and much less experience [than Western OEMs]. But we have good production experience from the joint ventures, and we know the supply firms well. So, we just buy the components, and put them together … Ideally, we buy whole systems from one global supplier, like exhaust systems, because they know the technology and requirements well.” (Interview, SAIC 180714.)

Rather than integrating tightly specified and specifically developed components into the system, SAIC uses an assembly approach that involves combining existing technologies and sub-systems, the characteristics of which are only loosely specified, so long as they easily fit together into a vehicle that performs well enough for demands of the Chinese mid-market.

This approach drastically reduces R&D expenses, and shortens the time for vehicle development. Rather than the industry average of 48 months for vehicle development, SAIC only needs 24 months to develop a new car. “For the MG branded vehicles, we only need two years for development, because we use the same components as the international joint ventures.” (Interview, SAIC 060814). This is made possible by relying heavily on existing technologies, for which less testing is required.

The system integration happens at a much looser level at SAIC, compared with Volkswagen. SAIC's approach requires less deep interaction with the supply firms because it does not become involved in the design of individual sub-components. SAIC also relies more on another group of suppliers: technology service providers for systems integration, especially for the vehicles based on the MG platform that SAIC acquired. While SAIC acquired some system integration capabilities with the acquisition of MG and its R&D centre in the UK, other Chinese firms have to rely almost completely on foreign supply firms.

3.1.3. The role of supplier firms

Interviewees from international supplier firms confirmed that their involvement in the R&D process of AMNEs and the Chinese EMNEs differs significantly for the same components supplied. “SAIC's development approach was very unfamiliar to us at first. With Western [assembly firms], we are involved very early on in the vehicle concept phase, to discuss the feasibility of the components and system performance requirements. By the time we start developing the product, we received the requirement specification – and that's it … With SAIC, or other Chinese [assembly firms], the requirements can change mid-way during the development. The process is way less defined and oftentimes quite uncertain and unforeseeable.” (Interview, BOSCH 130115.) Despite the somewhat uncertain development process, the same manager said BOSCH can hold deadlines and work with Chinese OEMs within their short development timeframes: “Typically, we are still able to develop the components in time, because the requirements specifications are not as demanding and we can draw on older, field-tested technologies … Often, we only need small adaptations.” (Interview, BOSCH 130115.)

A sales manager from Marquardt outlined the differences they experience in the R&D process between Western OEMs and Chinese OEMs: “[For Western OEMs:] Five years before SOP [start of production] we are brought in to the design studies. Because the design guys are more focused on what it's going to look like, than how it is actually going to work … We are brought in that early… to help the studio design functional switches.” (Interview, Marquardt 080515.)

“For Chinese OEMs, we have much shorter development times, and don’t work so closely with their engineers. For some switches – like seat adjustment switches we developed for Volkswagen – the same switches go into vehicles by local OEMs … When we supply local brands [i.e. Chinese OEMs], we can simply sell the finished components. Sometimes we need to change the housing. But the electronics and software, which take most engineering effort, stays the same.” (Interview, Marquardt 080515.)

Service providers for engineering services are also heavily involved in the development process of Chinese firms. For instance, MBtech Consulting, a global automotive technology service provider with the full competence to develop complete vehicles from concept to start of production, is currently involved in developing an entire vehicle for the Beijing-based Chinese assembly firm Beijing Automotive Industrial Company (BAIC), including design and platform adaptation (based on a platform BAIC acquired from Daimler). “We are in the lead for the development, because of our competency and experience with Daimler … We do the platform development, power-train integration, exhaust system integration, interior design setup etc. We design the body [exterior vehicle design] … We recently build a test facility here in China, and do all the system testing.” (Interview, MBtech 190115.) Essentially, MBtech – a German–French joint venture between Daimler and AKKA technologies – develops the vehicle that is built on a Daimler platform for BAIC. Similarly, the new Chinese OEM Qoros Auto did not develop its own vehicle, but outsourced the development to Magna, a large Italian automotive supply firm with experience mostly in production and assembly of vehicles, but also development of full vehicles. “Qoros sub-contracted Magna to basically design all of their vehicles, give them a turn-key plant.” (Interview, Marquardt 200515.).

Apart from the vehicle platform and body development, powertrains account for the highest proportion of R&D costs, accounting for approximately a third of the vehicle value. Ricardo, the leading engineering service provider for combustion engines, assists Chinese OEMs to develop engines for their vehicles. “The Chinese OEMs don’t have the capabilities to build combustion engines. They don’t want the competency… With their own engineers, they focus on e-drive systems [electronic engines]. So they buy our expertise, to develop combustion engines for them” (Interview, Ricardo 051114.) In all these cases, the managers of these projects confirmed that they go well beyond the supporting role usual in AMNEs, and instead take a leading role in projects from Chinese clients, who rely on their expertise to a much greater extent.

3.1.4. Findings on the role of suppliers compared

Comparing the role of supply firms in the vehicle development process of Volkswagen and SAIC we find that Volkswagen adopts a closely integrated and in-house driven approach to vehicle development that gives tightly specific development requirements to suppliers, delivered through close, two-way interaction over long cycles. Volkswagen acts as detailed system integrator working at the level of individual components and their interactions, in charge of the simultaneous engineering process, to develop vehicles of superior performance. SAIC, by contrast, base their development largely on assembling externally available technologies, often in the form of whole sub-systems, drawn from around the world, to create products that are improved through rapid iterations drawing on market feedback. SAIC loosely integrates the components, to develop vehicles that are good enough for the mid-market segment of the Chinese market.

In the conservative, “integrated system approach”, German firms have a close interaction with the external technology service providers and the key technology suppliers. While the components are produced and developed externally, the German firm is highly involved in their development process, controlling the R&D process through systems integration testing, and specifying the requirements. With its “simultaneous development process” Volkswagen goes beyond the “drawings approved” relationship as described by Asanuma (1989), who differentiates between two types of OEM–supplier relations: parts manufactured by supply firms based on the supply firms drawings (“drawings approved”), and parts manufactured by supply firms based on the OEM's drawings (“drawings supplied”), and because of the highly specialized and customized interfaces between components. This seems necessary because of Volkswagen's emphasis on the overall performance of the vehicle as a system, when, because of its integral nature, even small iterations of one component influence the performance of others (Fujimoto, 2007). An example of this sensitivity of the overall system is the so-called “defeat software” in Volkswagen's diesel affair: software that was illegally installed in large Volkswagen engines to detect emission test runs and alter the power-train performance and actual emissions to meet the standards only during test phases.

While transaction-cost theory might suggest that a make-strategy would be better for such integral products, such close interaction and cooperative simultaneous engineering processes seems to be the norm among Western automotive assemblers, as managers from General Motors and large global supply firms like BOSCH, Continental or Marquardt have confirmed. (Interviews, General Motors 240215, BOSCH 150115b, Continental 210515, Marquardt 200515.) These efforts are necessary if the supplier has superior knowledge of key technologies that are required for the product performance of the final vehicle compared with the assembler. If the external supplier can specialize in a key technology within the integrated system, it can devote more resources to this particular component and thereby create superior knowledge and technologies. Volkswagen only uses such elaborate “simultaneous engineering” approaches for key components of integral systems, when the supplier has superior technologies and knowledge. For non-integral (modular) components, normal buyer–-supplier relations apply.

SAIC, on the other hand, has no such sophisticated simultaneous engineering process in place. Instead, their “select and assemble” approach resembles that of ordinary buyer–supplier relations, even for components that would be considered highly integral (such as injection systems or engine cooling systems). Their supplier relations resemble a hands-off, price-driven mechanism even for key components, which are then assembled without the close overall system integration, with little regard for interactions between them that might impact the overall product performance. In combination with rapid iterations, their product development approach resembles the “bricolage” approach typical for young enterprises, in which the entrepreneurs recombine existing components to create a new product (Baker et al., 2003; Baker and Nelson, 2005; Duymedjian and Ruling, 2010). The degree of internal R&D capabilities impacts the degree to which a firm depends on its supply base for R&D. As other examples from our sample show, EMNEs with even fewer R&D capabilities, such as BAIC, depend even more on the international supply firms for their vehicle development – to the extent that the majority of core vehicle design and systems integration is done by external supply firms and service providers.

We term these two different approaches to vehicle development the “integrated system approach” and “select and assemble” approach, respectively. While Volkswagen follows the “integrated system approach”, typical for R&D-intensive products of an integrated architecture, SAIC's approach deviates significantly from the typical approach.

These differences in the development process enabled by differing supplier roles places different demands on the international R&D configurations between AMNEs and EMNEs (as also observed by Awate et al., 2012 and Awate et al., 2015). SAIC's approach to product development is made possible by the systems expertise of the suppliers in advanced economies to provide components that can be easily combined to provide adequate overall functionality, albeit not a top-performing system. But in order to access the key expertise, SAIC had to internationalize its R&D activities so as to provide sufficient frequency and quality of interaction to tap into the knowledge of foreign supply firms.

3.2. International configuration of R&D activities

We now turn to explore the different international R&D structures of Volkswagen and SAIC, that derive from the different approaches to systems integration and the different roles supply firms play for R&D. This is followed by an analysis of how the supply firms BOSCH and HASCO adopted their R&D configuration to enable the assemblers' diverging innovation strategies.

3.2.1. Volkswagen

The R&D activities at Volkswagen are broadly divided into research (advanced engineering, technology scouting, market research and processing methods) and development (including product design, core product development and adaptations to the market). Research is decoupled from the vehicle development process, and has no direct impact on the simultaneous engineering process and the role of supply firms in the process. The development process is again divided into core development of the vehicles in the simultaneous development process, and the adaptation process, if readily developed vehicles are rolled out in a new market that requires customization to meet local emissions standards or because of consumer tastes. Supply firms play a crucial role in the core development process – which involves the designing and development of new vehicles, including all components, over the full four-year process. While supply firms may also be involved in the adaptation and customization to other markets, this process is much shorter and requires much less interaction between assembler and supplier.

For the Volkswagen branded vehicles, Volkswagen has six development centres in four different countries (summarized in Table 3). Core development is located in the R&D centre at headquarters in Wolfsburg, Germany (Fig. 2). At this location, the most intensive interaction and involvement of the supply firms is required. “We demand our key suppliers to locate their R&D centre close to ours … With some engineer teams [from the supply firms] we have meetings a regular as on a weekly basis.” (Interview, Volkswagen 130515b.) With the introduction of the globally used MQB vehicle platform in 2010, Volkswagen centralized core development activities. Previously, Volkswagen had developed specifically targeted vehicles in China and Brazil, the

Table 2
Overview of Interviews.

Company	# of interviews (English / German / Chinese)	Hierarchical level	Functional areas
Volkswagen			
Headquarters	10 (0/10/0)	Director; Dep. Manager; Project Managers	R&D; Purchasing; Production
VW Group China	4 (1/3/0)	Director; General secretary; Project Manager	R&D; Purchasing
FAW-VW	2 (0/2/0)	Director	R&D; Purchasing
SAIC			
Headquarters	2 (1/0/1)	Director; Manager	R&D; M&A task force
S-VW	1 (0/1/0)	Director	R&D
BOSCH			
Headquarters	2 (0/2/0)	Member of the board; Director	China Region; Global Purchasing
Bosch China	5 (1/4/0)	CEO; Executive VP; VP; Project Manager	R&D; Sales; Purchasing
UAES (JV)	1 (1/0/0)	Director	R&D
HASCO			
Headquarters	1 (1/0/0)	Director	Business Development
Yanfeng	1 (1/0/0)	Director	Sales
YAPP	2 (2/0/0)	Director	R&D; Sales
Additional Interviews			
General Motors	2 (2/0/0)	Director	Procurement, R&D
Ricardo	1 (1/0/0)	Director	Combustion Engines
MBtech China	2 (2/0/0)	CEO	
Marquardt	2 (1/1/0)	Department Manager; Project Manager	R&D; Quality
Continental	1 (1/0/0)	CEO	
Consulting firms	3 (2/1/0)	Partner	Automotive Centre

Table 3
Number of engineers in the R&D Centres of the Volkswagen Brand.

	Germany	US	Brazil	VW China	FAW-VW	S-VW
Number of employees	> 10,000	> 1000	> 500	> 400	1220	> 1400

VW Bora and VW Lavida (based on the old Jetta platform), and the VW Gol (based on the old Golf platform). Even though the vehicles were derivatives of previous VW vehicles that were developed in Wolfsburg, the local development in Brazil and China went beyond product adaptation, to include external and internal design, and engine development for flexfuel systems in Brazil.

The other R&D centres are localized in Volkswagen's three biggest foreign markets: the US, Brazil and China. The only country with more than one R&D centre is China, where Volkswagen established three R&D centres: one in each joint venture (with SAIC and FAW), and one central R&D centre that coordinates between the two joint ventures and the headquarters in Germany. Each of the R&D centres in the foreign market is responsible for product adaptation to the local market (Fig. 2). While collocation of R&D centres from the supply firms is an advantage, it is not a requirement by Volkswagen, as the level of interaction is not as high for product adaptation.

3.2.2. SAIC

As one of the big four Chinese automotive assembly firms, supported by the government to become a "national champion", SAIC was one of the first Chinese automotive producers to have established an offshore R&D centre for the purposes of accelerated learning and knowledge creation. As early as 2005, SAIC set up an R&D centre in the UK (Table 4). In 2007, after the acquisition and subsequent integration of MG into the SAIC corporation, the UK based R&D centre was merged with the former R&D centre of MG in the UK, to become the main R&D centre for SAIC. SAIC's core vehicle development happens at the R&D centre in Birmingham, UK, for the development of SAIC's 11 different vehicles (MG GS, MG 7, MG 6, MG 3, Roewe E50, Roewe 350, Roewe 550, Roewe 750, Roewe 950, Roewe W5 and Maxus). Locating core R&D in advanced economies enables interface with suppliers to obtain the understanding necessary to enable them to loosely integrate components and sub-systems into the design of the final vehicle, and hence the suppliers' knowledge embodied within them. The purpose is not to learn the technologies but to access sufficient understanding of the components and modules to enable them to be integrated into a final vehicle design (often with the help of service providers also located in

Table 4
Number of engineers in the R&D Centres of SAIC.

	United Kingdom	China Shanghai	China Nanjing
Number of employees	> 300	> 400	> 100

advanced economies). "The focus of the SMTC UK [R&D centre] is to develop the product architecture for the MG and Roewe vehicles … We develop the integrated vehicle designs, and some components … Most components are developed by the supply firms. We are not involved in their development; we don't develop much together with supply firms." (Interview, SAIC 250515.) Another interviewee highlighted the importance to locate the R&D centre in Europe: "We need to benefit from the knowledge in the European automotive industry … Being near our core suppliers is important, so that we can effectively integrate their components into our vehicle platforms." (Interview, SAIC 060814.)

The two R&D centres in China are responsible for the adaptation of the vehicles to the Chinese market (Fig. 2). Since China is SAIC's core market, the adaptation activities go beyond that of Volkswagen, to include external and internal vehicle design based on the MG vehicle platform, and development of the user interface of the entertainment system.

3.2.3. BOSCH

As one of the largest automotive suppliers in the world, serving customers in different countries, BOSCH has the most internationalized R&D structure of our four cases, with 13 R&D locations in total, of which five are in their home country, Germany, and eight in foreign locations in China, India, Japan, Russia, Singapore and the USA. As a systems supplier of highly integral components, BOSCH is deeply involved in the R&D process of OEMs, which necessitates them to collocate their regional R&D centres in close geographic proximity to their customers' R&D centres so as to be able to participate in the simultaneous engineering process of its customers. "We need to be close to our customers … Only through frequent meetings we can meet the demand of our clients, and build good relationships." (Interview, BOSCH 130115.)

However, the role of BOSCH differs to that of Western OEMs vis-à-vis Chinese OEMs. "For global OEMs, we are working together very closely in very structured development programs … COEMs, as we call them [Chinese OEMs], have very different approaches [to development] … much less structured." (Interview, BOSCH 130115.) "They have much less experience with the technology, and often require changes [during the process]." (Interview, BOSCH 130115.) "In the end, we mostly sell standardized and available products that need very

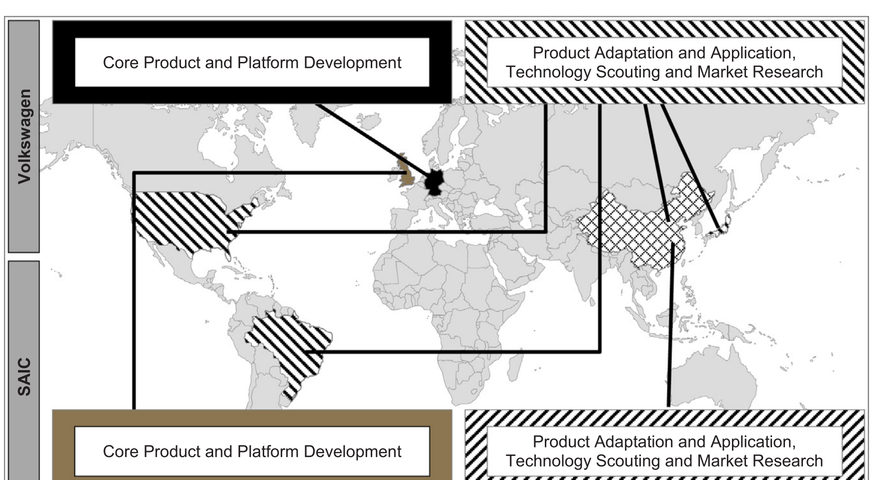

Fig. 2. International R&D Centres of Volkswagen and SAIC.

little adaptation and much less alignment and systems integration to other components." (Interview, BOSCH 130115.)

3.2.4. HASCO

HASCO has two subsidiaries with highly international R&D configurations, Yanfeng and YAPP, which are described separately.

Yanfeng originated from a joint venture between HASCO and Visteon for electronic components. Due to the companies' history, the USA plays a central role in the R&D activities of Yanfeng's electronics business. As of 2015, Yanfeng also has established an R&D location in Shanghai, China, which is mainly involved with product adaptation for the Chinese market. The Chinese R&D centre is gradually upgrading its capabilities, and most testing facilities have been relocated to China. However, core platform development is located in the USA.

YAPP is a global market leader for plastic fuel tanks. The company operates three international R&D locations, in Germany, India and Australia. Additionally, through the recent acquisition of their former alliance partner (since 2010), ABC Group Fuel Systems Inc. in 2014, YAPP acquired the manufacturing plant and associated R&D centre of ABC in the USA. The primary function of the German and US centres is research and product development and to deepen the technological ties with innovation systems on site, as well as to enable simultaneous engineering of products for local assembly groups. The other R&D centres in India and Australia serve the purpose of product adaptation and technology scouting (see Fig. 3).

Both subsidiaries have core development capabilities at home in China, as well as elsewhere. "We need our product development in the US, as this is our traditional R&D centre from Visteon, with experienced engineers and development teams … It is also important to serve our customers in the US. We have very close relationships [with US customers] for product development and customization." (Interview, Yanfeng 190714a.)

Similarly, YAPP highlighted the close ties to Western OEMs for product development: "The Western clients are more demanding … We had to develop a process for multi-layer fuel tanks [for Western OEMS]. The Chinese OEMs don't have such demands. They buy the products as we have them. Of course, we need to adapt size and shape, but not any core development with new materials or processes." (Interview, YAPP 260714.)

3.2.5. R&D configurations compared

As we see from these data, overseas R&D locations play very different roles in the configurations of German and Chinese firms (summarized in Table 5). The core product development is located in the advanced economies, while product adaptation, technology scouting and market knowledge creation is localized in the emerging economies. This is even the case for the Chinese OEM in our sample, which has internationalized its R&D to localize core R&D activities in the advanced economies.

The purpose of the international R&D centres differs between OEM and supplier. The principal role for OEMS' R&D centres in advanced economies is core product development, as building the relevant capabilities is more effective in developed markets, because that is where the OEMs can hire engineers with the necessary experience – experience that is often lacking in their home country (Awate et al., 2015). The principle role for R&D centres in foreign locations is to access market-specific knowledge such as customer preferences (e.g. customer entertainment systems, interior design, chrome or colour choice, gear shift preferences, engine size preferences, chassis suspension preferences, seating preferences etc.), and to adapt existing technologies to the peculiarities of local demand (such as emissions standards or quality and safety regulations). This seems to reflect the fact that the knowledge necessary for these specific adaptations is best created in the local environment through an embedded R&D centre close to the customer and regulatory body.

For supply firms, by contrast, the role of foreign R&D centres is focused on knowledge interactions with the OEMs from the advanced markets. The supply firms mirror the R&D configuration of the OEMs, to collocate core R&D activities to the core R&D activities of Western OEMs. By collocating core development to the core development of the OEMs, the supply firms enable the innovation and development in the simultaneous development process of Western OEMs (Grimpe and Sofka, 2016; Lu et al., 2016).

4. Possible extensions to existing theory

Given the important differences we observe between AMNEs and Chinese EMNEs in terms of both the role suppliers play in their product development processes and the configurations of their international R&D, we now turn to examine the voracity of existing theory in explaining the reasons for these differences.

4.1. Product configuration and the role of suppliers

Extant literature that characterizes different product architectures in terms of integral versus modular and closed versus open (Ulrich, 1995; Fine, 1998; Baldwin and Clark, 2000; Fujimoto, 2007) is depicted in Fig. 4. The well-defined interfaces in modular architectures enable components to be interchangeable in different configurations, without compromising performance of the final product (van Schewick 2010;

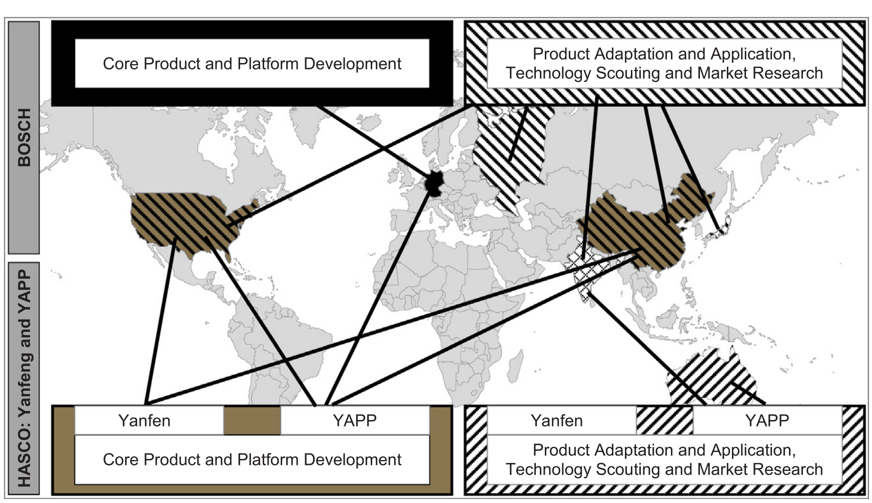

Fig. 3. International R&D Centres of BOSCH and HASCO.

Table 5
Location and function of R&D Centres for OEMs.

	Advanced economies					Emerging economies				
	Germany	USA	UK	Japan	Australia	China	Brazil	Singapore	Russia	India
Volkswagen	C, T, S, R, M	T		T, M		T, A, S	A			
SAIC			C, T			A, S, R				
BOSCH	C, R, M	C, T, A, S	C, T	T, A, S		A, S	A, S	S	A, S	A, S
HASCO	C, A, T, S	C, A, T, S			A	P, R, M			A	

Functions:
Development:
C (product design; core development for products).
A (adaptation and customization of products for a specific market).
Research: .
T (technology scouting; competitor analysis through reverse engineering; collaborations with universities).
S (specific market knowledge).
R (research: advance engineering; materials science; collaborations with universities).
M (processing and production methods).

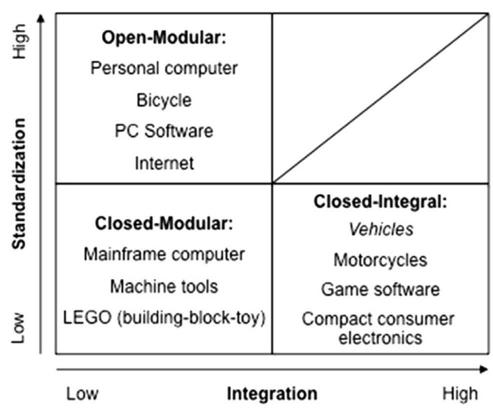

Fig. 4. Types of Product Architecture (from Fujimoto, 2007).

Fujimoto, 2007; Garud and Kumaraswamy, 1993). Open modular architectures take this one step further by adopting widely supported interface standards enabling the use of components available from a variety if suppliers in the open market (Fujimoto, 2007). In integral architectures, by contrast, components are tightly coupled, so that design and production processes need to be closely coordinated so as to create optimal linkages between components to ensure optimum product performance (Ulrich, 1995; Ulrich and Eppinger, 2004; Park and Ro, 2013).

A number of key influences on the product architecture a firm will choose have been identified. First, it is argued that firms who seek to offer more innovative products to higher-end market segments, competing on superior performance, will need to deal with less familiar technologies and uncertain customer demand (Adner and Levinthal, 2001; Christensen, 1997). As a result, they will need to experiment with components in new combinations where interdependencies are high and interfaces undefined, necessitating an integral product architecture (Park and Ro, 2013; Brem et al., 2016). Firms competing at the lower end of the market where technologies and component combinations are more standardized, by contrast, will have the option to choose a more modular architecture (Utterback, 1994; Christensen et al., 2002; Brem et al., 2016). Second, firms that choose to compete on speed-to-market and cost reduction in these lower-end segments will tend to choose a modular product architecture (Baldwin and Clark, 2000).

Third, transaction cost theory (Williamson, 1996) suggests that as the technologies underpinning a product matures and is better understood, it will become increasingly possible to standardize the interfaces between its components, leading to a more modular architecture. These more modular structures will make it viable for firms to outsource more of the product components and their development to suppliers (Casson, 1986; Williamson, 2002; Contractor et al., 2010). The more integral the product, by contrast, the less the opportunities to outsource R&D and product development (Park and Ro, 2013).

Thus if AMNEs tend to compete on innovation and performance to appeal to higher-end segments while EMNEs tend to compete on cost and speed in lower-end segments, then EMNEs would, if possible, choose more modular structures (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). This, in turn, would result in EMNEs relying more on suppliers in R&D and product development (Brem et al., 2016).

Most of the existing literature, however, suggests there should be little scope to adjust the product architecture in automobiles, because they are systemic, closed integral products (Hill, 1989; Fujimoto, 2007; Sturgeon et al., 2009). Yet we find different choices about product architecture lie at the heart of the different roles of suppliers in product development and different international R&D configurations we observe.

Our results suggest that a key reason why EMNEs are able to choose a different product architecture than that traditionally adopted by established AMNEs is that suppliers are willing to adjust their offerings and play a larger role in innovation by incorporating new knowledge into the components and sub-assemblies they supply (Isaksson et al., 2016). For EMNEs, suppliers act as an important source of “packaged” knowledge, embodied in modules and sub-assemblies.

Because they can rely on suppliers to contribute technology and design to core vehicle modules that are “plug compatible”, EMNE assemblers are able to adopt a “select and assemble” innovation strategy (Baker and Nelson, 2005; Duymedjian and Ruling, 2010). This involves a simplified product development process that minimizes the systemic interactions between components (Zeng and Williamson, 2007; Wang and Kimble, 2010; Williamson, 2010). As a result, they are able to focus a stream of incremental innovations that can be launched into the vehicle quickly and have adequate performance for the mid-priced market segment in China (Brandt and Thun, 2010). EMNEs can thus compete on the basis of rapid responsiveness to changing market needs (Sturgeon, 2002; Buckley, 2009; Zeschky et al., 2014).

This positioning and innovation strategy, enabled by suppliers, differentiates EMNEs from AMNE competitors who are focused on creating more significant innovations that depend on systemic optimization of advances in multiple components. In the case of AMNEs, the suppliers participate much more directly in a process of new knowledge co-creation with assemblers that innovates by creating systemically optimized improvements in vehicle performance (Colombo et al., 2011; Bäck and Mohtamäki, 2015; Manning, 2017). This systemic optimization also generally requires a longer time cycle to complete, higher investment and better internal knowledge and capacity within the assembly firm (Hill, 1989; Baldwin and Clark, 2000).

4.2. Internationalization of R&D

Prior research has highlighted the fact that the increasingly global nature of competition has necessitated that contemporary businesses search for knowledge and capabilities beyond their home markets (Doz et al., 2001; Davis and Meyer, 2004; Criscuolo, 2009; Dunning and Lundan, 2009). Because of the tacit nature of knowledge (Polyani, 1964), and the stickiness of knowledge to certain geographic locations (Szulanski, 1996), however, firms need to go abroad to explore and absorb knowledge that is location-bound (Kogut, 1991; Penner-Hahn and Shaver, 2005).

A multinational can gain two main potential advantages from expanding its knowledge base in these ways. First, it can enhance its local knowledge of specific markets, allowing it to modify and exploit the knowledge developed at home to better address the specific demands in a foreign market (Alcacer and Chung, 2007; Cantwell and Mudambi, 2005; Chung and Alcacer, 2002; Driffield et al., 2010; Song et al., 2011; Belderbos et al., 2015; Sartor and Beamish, 2015). Second, it can seek external knowledge to import and feed back into its product innovation processes to enhance its ability to create value (Griffith et al., 2006; Driffield and Love, 2007; Todo and Shimizutani, 2008; Criscuolo, 2009; Belderbos et al., 2013).

It has also been shown, however, that the effectiveness of foreign R&D in enhancing a firm's domestic competitiveness tends to increase in line with the quality of its domestic R&D capabilities (Todo and Shimizutani, 2008). This reflects that fact that effectively integrating externally sourced knowledge at home requires a sufficient level of absorptive capacity built up through domestic R&D activities (Cohen and Levinthal, 1989, 1990; Penner-Hahn and Shaver, 2005). EMNEs have less R&D experience and hence lower absorptive capacity than AMNEs. This would imply that EMNEs can benefit less from internationalizing their R&D activities.

In sharp contrast to this prediction, we find that EMNEs have extensively internationalized their R&D centres. Our research explains this behaviour by the fact that suppliers have been willing to act in ways that enable EMNEs to side-step some of the limitations of their absorptive capacity and so benefit from dispersing their R&D centres around the world. Specifically, the fact that suppliers have been willing to serve EMNEs in ways that enable them to adopt a different innovation strategy from those that are prevalent among AMNEs, means that the role of EMNEs' international R&D centres can also change.

Awate et. al. (2015) have already shown that EMNEs use foreign R&D centres to access new knowledge for catch-up with industry leaders. AMNEs, by contrast, internationalize their R&D configuration with the aim of innovation that pushes the boundaries of product performance. Awate et al. (2015) do not explore, however, how differences in the innovation processes and choice of product architecture between AMNEs and EMNEs impact the role of foreign R&D centres. Nor do they study the specific differences in the types of knowledge these foreign R&D centres capture, or how these differences are underpinned by the role of suppliers.

Extending Awate et al. (2015), our results show that the differing role of suppliers enables EMNEs to adopt different innovation processes and product architectures from AMNEs which, in turn, alters the purpose of these foreign R&D centres. EMNEs such as SAIC collocate their R&D in physically distant, mature markets with leading international suppliers in order to source the knowledge they need to integrate the modules and sub-assemblies sourced from suppliers. The knowledge necessary to successfully integrate these modules may itself be tacit and location-bound (Iwasa and Odagiri, 2004; Singh, 2008), so requiring frequent and sustained interactions and hence co-location with suppliers in order to access it (Isaksson et al., 2016; Manning, 2017), even though the goal is not deep learning of the underlying technologies.

Our results also imply that, because firms can adopt either an integrated system or a "select and assemble" approach to innovation, the type of product development process it chooses needs to be explicitly accounted in order to properly model the antecedents of a firm's international configuration of R&D, along with traditional factors such as relative costs and the global distribution of different types of knowledge (Kuemmerle, 1997; Gassmann and von Zedtwitz, 1999). The nature of a firm's product development process not only influences the extent to which it disperses its R&D internationally, but also the role that overseas R&D centres play in that process.

This finding suggests that the geographic overlap between where AMNEs and EMNEs locate their foreign R&D centres will be incomplete. Both will locate where they can be proximate to leading suppliers, but for different reasons: AMNEs because these locations are often the source of leading-edge technologies; and EMNEs because they need to work closely with suppliers. AMNEs, however, are also likely to locate additional R&D centres where there are potentially interesting new technologies (e.g. in related industries) even where existing suppliers are absent. EMNEs, by contrast, can be expected only to incorporate locations into their international R&D configuration where there are suppliers who can provide them with modules and sub-assemblies that embody the knowledge they need.

To facilitate the R&D strategies of EMNEs, suppliers also have to adapt their own R&D configurations. Both of HASCO's subsidiaries, for example, located core development activities in the advanced economies, so that they are able to serve key customers in the simultaneous development process of the "integrated system approach". In this case, the R&D configuration is not driven by sourcing externally available knowledge, but by enabling the R&D approach of their EMNE customers (Birkinshaw and Fey, 2005; Awate et al., 2015).

When they serve AMNEs, knowledge generation plays an important part in suppliers' R&D configurations. Because buyer innovation has a positive and significant impact on supplier innovation (Isaksson et al., 2016), suppliers are encouraged to collocate R&D activities with those of AMNEs that are at the forefront of technological development.

Finally, the strategies adopted by EMNEs, with the help of their suppliers, suggests that the traditional role and importance of absorptive capacity as critical to success of overseas R&D centres needs to be re-thought (Cohen and Levinthal, 1990). Using international R&D centres to access knowledge embodied in components and sub-systems that can be assembled into a functional vehicle places fewer demands on their absorptive capacity, compared with AMNEs' strategy of internalizing component-specific knowledge needed to optimize the complex interactions between components required to deliver top performance. Thus, the absorptive capacity and R&D capability of EMNEs both locally and at home plays a less important role. By using suppliers in a different way, enabling their international R&D centres to play a different role, EMNEs are able to bypass an important potential weakness and to catch up with AMNEs more quickly than would be expected if they had to undertake the slow and difficult task of developing their absorptive capacity to access and integrate fundament new technologies that were not embodied in modules or sub-assemblies (Mathews, 2006; Bertrand and Mol, 2013).

5. Implications for the future competition in the global automotive industry

In addition to these implications for the development of theory concerning the role of suppliers in shaping choices about innovation strategies and international R&D configurations, our results also shed light on the likely evolution of competition within the global automotive industry, including the "fight for the middle market" in emerging markets such as China and the scope for EMNEs to disrupt the strategies adopted by global AMNE incumbents.

The different innovation strategies and the differing buyer–supplier relations adopted by EMNEs and AMNEs become a source of competitive advantage under different market conditions (Fine, 1998; Eisenhardt and Martin, 2000; Teece, 2014). In the context of the Chinese mid-market, SAIC has been able to create new non-ordinary firm-specific advantages through its innovative R&D approach (Brandt and Thun, 2010; Ramamurti, 2012; Williamson, 2016). Through the hands-off, off-the-shelf, "select and assemble" approach, SAIC has created a low-cost R&D and product development process for final products "good enough" for a growing segment and mass market (Baker and Nelson, 2005; Wan et al., 2014). Using its deep knowledge of local demand conditions, SAIC has developed the key components required to create disruptive innovation without ordinary resources (Christensen and Raynor, 2003; Christensen, 2006). Gaps in technology and knowledge can be effectively bridged by sourcing leading-edge components and tapping into the services of expert firms supplying the industry.

Furthermore, SAIC has created a unique advantage through their speed-to-market strategy of the fast vehicle development process that allows for rapid responses to changing consumer demands (Wang and Kimble, 2010). This may be a significant future advantage as the automotive industry is poised for major technological change including the development of electrified powertrains (hybrid and electric vehicles), connected cars and revolutions in driver assistance technologies towards autonomous driving. Shorter R&D cycles also allow them to launch more frequent model face-lifts and technology upgrades into the market. This process innovation creates a crucial dynamic capability which could underpin future competitive advantages for SAIC (Teece and Pisano, 1994; Teece et al., 1997).

Volkswagen, on the other hand, maintains its advantages as a technology leader in the industry, important for advanced markets. Through excellent integration of externally sourced components and elaborate simultaneous product development processes, Volkswagen can fully appreciate the interactions between components in the integrated architecture, to achieve maximum product performance (Pavitt, 2003; Singh, 2008). While this is necessary to satisfy consumer demand in mature markets, they "over-engineer" their vehicles for the rapidly growing Chinese mid-market segment, for which they have failed to develop an optimized "good enough" vehicle (Markides, 2006).

The novel product architecture of SAIC, therefore, has the potential for disruptive innovation in the Chinese mid-market. According to Christensen, disruptive innovations are initially inferior to mainstream technologies but offer a superior price to conquer a niche market (Christensen, 1997; Christensen and Raynor, 2003). The products are subsequently upgraded to close the gap to their foreign competition and become "good enough" to serve the mainstream market (Christensen and Raynor, 2003; Markides, 2012; Wan et al., 2014). This is especially the case if incumbent firms over-engineer their products, resulting in overshooting the performance of the mainstream technology that exceeds the demand of mainstream customers. As Henderson and Clark (1990) point out, incumbent firms find it difficult to cope with the architectural innovation of new entrants.

AMNEs struggle to adopt the product architecture of EMNEs even for products targeted at emerging market customers. This is because even when seeking to supply these markets the AMNEs we studied believe it is advantageous to develop the vehicles centrally. This strategy allows them to draw on deep accumulated engineering and design experience. In part, it also reflects a tendency for their engineers and management at home to resist the approach of simply buying and integrating existing sub-module components because they see it as producing sub-optimal results. As a result, SAIC's novel product architecture and R&D approach has the potential to result in disruptive innovation in the context of the Chinese automotive market, allowing SAIC achieve "good enough" vehicles with a superior price compared to their AMNE cousins.

This disruptive impact may also apply to other emerging markets. AMNEs' understanding of the "mass market" comes from their experience in mature markets. While Volkswagen, for example, produces vehicles suitable for the mid-market in an advanced economy such as Germany, their products "overshoot" performance for the mid-market in China (Christensen, 1997; Wan et al., 2014). The deeper understanding of the domestic Chinese enjoyed by Chinese EMNEs, therefore, may enable them to build their global market reach and share by disrupting other emerging markets around the world where incumbent AMNEs also overshoot the performance requirements of the mid-market.

6. Conclusion

Our findings suggest that suppliers play a key role in enabling AMNEs and EMNEs to make different choices about product architecture and innovation strategies. These differences in innovation strategy, in turn, result in different roles for foreign R&D centres in terms of the type of knowledge they seek to access, and hence a different international configuration of R&D for AMNEs compared with EMNEs.

The resulting divergence between EMNEs and AMNEs leads to competitive advantages in different segments of the global automotive market. By using more modular architectures and replying more heavily on suppliers in their innovation processes, Chinese competitors are able to deliver offerings attuned to the needs of the mid-market segments at lower costs and higher speed than the German cousins. This opens up the potential for the Chinese to bring disruptive competition to the global automotive industry, especially in emerging markets.

These findings also have significant implications for theories seeking to explain the international configuration of R&D (Awate et al., 2015; Hsu et al., 2015). They imply that supplier behaviour and its impacts on available choices of product architecture and the product development process need to be explicitly incorporated into models explaining the international configuration of R&D. They also point to a need to re-think the nature and role of absorptive capacity in determining the benefits that can be obtained from establishing foreign R&D centres, given that the willingness of suppliers to adapt to the needs of EMNEs mean that they can side-step some of the limitations imposed by lack of absorptive capacity and R&D experience.

We believe these patterns are likely to be replicated in other industries. Earlier research (e.g. Nolan, 2001; Zeng and Williamson, 2007) has found that suppliers have played a key role in helping Chinese firms to innovate across a number of sectors. This is especially the case where new technologies are embodied in product sub-modules or processing equipment so that product designers and manufacturers can innovate by integrating these modules into new products or equipment into new processes. This is not only true for China. Much of the innovation at Brazil's Embraer, for example, has been based on novel ways of integrating knowledge and technologies embodied in modules from suppliers (Armellini et al., 2014). It would therefore be worthwhile for further research to examine the relationships between supplier role, innovation strategy, international R&D configuration and competitiveness in other industries and other country contexts.

Our results suggest fruitful future research into the changing role of suppliers in innovation and product development and its links to governance approaches and "make versus buy" decisions (McDermott and Corredoira, 2010; Rosell and Lakemond, 2012; Casson, 2013) – an under-researched area, given the increased specialization on core activities and increased outsourcing of important but non-core activities (Contractor et al., 2010; Bertrand and Mol, 2013; Milberg and Winkler, 2013). Similarly, the impact of supplier behaviour on the competitive advantages enjoyed by EMNEs and the implications of disruptive innovation and global rivalry between EMNEs and AMNEs warrants further study (Ramamurti, 2012; Sutherland et al., 2017).

These new research directions also point to the limitations of our conclusions based on cases of just two pairs of firms which may not be representative. Likewise, the automotive industry maybe idiosyncratic, given that it has a high degree of interaction and interdependence between assemblers and suppliers, long product life cycles and requires high fixed-cost technology and R&D investments (Sturgeon et al., 2008, 2009). Product characteristics in other industries may result in a very different menu of choices for product architecture and innovation processes and less intense interactions with suppliers in R&D.

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