# *Production networks and innovation in the semi-periphery: the transition to electric vehicles in South Korea and Spain*

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# Production Networks and Innovation in the Semi-periphery: The Transition to Electric Vehicles in South Korea and Spain

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**Abstract**
What determines the ability of firms based in New Advanced Economies to generate innovation in the transition to electric vehicles (EVs)? Under what conditions are they more likely to break with their established pattern as fast followers to create innovation that is new to the world? To address these questions, we introduce a meso-level framework focused on the organization of global production networks. The framework examines three aspects of such networks: the position of the firm within the network, the number of lead firms, and the links between lead firms and suppliers. We illustrate the explanatory power of our framework through the cases of South Korea and Spain, the two New Advanced Economies with the largest automotive sectors. We characterize Korea's production network as a unipolar, captive structure and Spain's as part of an EU-wide multipolar, modular production network. We argue that contrary to common perceptions, Korea's structure delayed the transition to EV's and strengthened Korea's role as a fast follower. Meanwhile, Spain's embeddedness in the EU production network offered significant opportunities for turnkey suppliers to generate novel innovation despite the absence of a domestic lead firm.

**Keywords** Innovation · Global production networks · Electric vehicles · Semi-periphery · Spain · South Korea

## Introduction

Until recently, the automotive industry was considered a mature industry with a predictable structure (Schulze1 et al. 2015). The transition from internal combustion engines to electric vehicles (EVs) is rapidly transforming the sector. The global

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EV market took off in 2020 and has since grown rapidly. In 2022, global sales of EVs reached 10.5 million vehicles, an increase of 55% over 2020, which brings the global stock of EVs to 27 million ((IEA 2022; Irle 2023).

EVs challenge the business models of legacy automakers and parts and components suppliers. Electric motors have up to 75% fewer moving parts than internal combustion engines, which simplifies vehicle structure and lowers barriers to entry into auto-making. Ipso facto, new entrants such as Tesla, BAIC, and BYD compete directly with legacy automakers while being less encumbered by sunk investments in organizational and physical structures. EVs also pose an existential challenge for legacy parts and components suppliers. EVs require large amounts of specialized hardware, but some of the systems used in industrial combustion engines such as elaborate gears, expensive exhaust systems or shankcrafts are no longer necessary. Other systems, such as steering, breaking and propulsion, operate differently in EVs, requiring redesign and retooling (Reichert 2017; Sedgwick 2017). Electric batteries also require a different set of materials and are heavier than conventional engines, which affects the types and degrees of metal used to manufacture cars and interiors (Onstad 2018; Home 2018). Combined, these changes may place up to 75% of the top 100 suppliers at the risk of oblivion (Sedgwick 2017).

To respond to these impending challenges, legacy automakers and suppliers have little choice but to innovate (Romer 1990; Teece 2012). But what determines their ability to do so? This question takes on a particular meaning in the context of New Advanced Economies (NAEs)[1], a group of semi-peripheral countries that achieved advanced country status in the 2000s (Garcia Calvo 2021a). Unlike advanced economies, NAEs reached the efficiency frontier on the basis of knowledge absorption and incremental improvements rather than invention (Amsden 1998; Kim 1997; Guillén and Tschoegl 2008). They have since refrained from generating novel (or new to the world) innovation[2], acting instead as fast followers and second innovators (Wong 2011; Breznitz and Orston 2018). NAEs are also at a disadvantage relative to late-late industrializers that have recently entered the sector, including China. NAEs cannot compete on costs because they have become too prosperous and salaries and other expenses have risen accordingly. Furthermore, NAEs that have large automotive sectors such as South Korea (Korea) and Spain face huge barriers to transformation in the form of sunk physical investments, complex organizational structures, and labor commitments.

[1] NAEs are countries whose per capita incomes were between 20 and 50% of the US' per capita income in 1980 but raised their standard of living above 50% of the US' by the mid-2010s and which have complex production structures, defined as being the home base of at least one lead firm that controls the process of design, production, and distribution of a global production network, has global market power, and a recognizable brand name (Garcia Calvo 2021a).

[2] Breznitz (2021) defines novel innovation as "the transformation of new-to-the-world inventions into useful innovations." This paper uses the terms novel innovation and first-mover innovation indistinctly to refer to innovation that is new to the world as opposed to new to the country or new to the firm. The purpose is to distinguish between the patterns of fastfollowership or second-innovation that have hitherto predominated in New Advanced Economies and "truly new" innovation. It is worth mentioning that novel innovation, as used here, can be either incremental or radical, so long as the innovative processes or outputs are new to the world.

Considering these factors, we reframe our question as follows: What determines the ability of NAE firms in countries with large, established automotive sectors such as Korea and Spain to generate the innovation necessary to compete in EVs? Under what conditions are they more likely to break the glass ceiling of fast-followership to become novel innovators?

Political economists in the institutionalist tradition (Whitley 1999; Hall and Soskice 2001) have approached innovation from the point of view of national institutions. Yet, much of this literature tends to be based on analyses of consolidated advanced economies such as Germany, the US, and Japan, while paying little attention to the particularities of NAEs. Developmental state scholars (Haggard 1990, 2018; Johnson 1982; Wade 1990; Amsden 1998) partly fill in this gap. However, they concentrate on characterizing catch-up models that rely on absorbing innovation in the context of mature, stable industries. Such models are, therefore, less useful to explain the development of novel or new-to-the-world innovation in the context of high technological, economic, and temporal uncertainty such as the transition to EVs (Wong 2011). Business scholars (Abernathy and Clark 1983; Henderson et al. 1990; Pisano 2015, 2019; O'Reilly and Tushman 2008, 2016) propose micro-level frameworks that underscore the importance of firm-level features such as size and ambidexterity[3] in innovation. However, they tend to underplay the role of context in providing access to the resources, capabilities, and incentives necessary to succeed at innovation (Jackson and Deeg 2008, 2019).

Instead, our paper addresses these gaps by combining an institutional perspective that takes into account NAEs' tendency to act as second-movers, and a meso-level perspective that focuses on the characteristics of global production networks, the multi-firm structures that determine the contours of competitiveness in most complex manufacturing sectors (Kogut 1985; Coe and Yeung 2015; Baldwin 2016). Our approach is based on two assumptions: that the organization of global production networks can take multiple forms, each with distinct strengths and weaknesses (Gereffi et al. 2005) and that the disaggregated structure of global production networks provides multiple entry points to innovation across the production chain (Breznitz 2021). We present a framework that looks at three aspects of global production networks: the position of the firm within the network (lead firm or supplier), the number of lead firms (unipolar or multipolar networks), and the type of links that bind lead firms and suppliers (captive or modular links). We argue that these factors affect the type of innovation a firm may undertake, firms' incentives for novel innovation, and firms' autonomy to initiate innovation respectively. We argue that, combined, these three factors shape the propensity of NAE firms in complex industries, such as the automotive sector, to break the glass ceiling of novel innovation.

We illustrate our argument through an analysis of the Korean and Spanish automotive sectors as they transition to EVs. Korea and Spain epitomize the concept of

[3] O'Reilly and Tushman (2013) define ambidexterity as "the ability of an organization to both explore and exploit—to compete in mature technologies and markets where efficiency, control, and incremental improvement are prized and to also compete in new technologies and markets where flexibility, autonomy, and experimentation are needed" (O'Reilly and Tushman 2013).

a NAE (Garcia Calvo 2021a). The two countries experienced rapid industrialization trajectories in the 1960s and 1970s, immediately followed by upgrading processes that transformed them into advanced economies. Both countries have large, legacy automotive sectors. In 2021, Korea and Spain were, respectively, the 5th and the 9th world's largest vehicle producers (OICA 2023). However, the production structures of the two countries are vastly different, providing room for our analysis. Korea is home to one of the world's largest legacy automakers and several large domestic suppliers that are part of the same group as the automaker (Guillén 2010; Berylls 2021). By contrast, Spain's automotive sector has no domestic automaker and is composed exclusively of suppliers, including several large, independent suppliers (Guillén 2010; Garcia Calvo 2021b). Spain is also fully embedded in a larger, EU-wide production network involving multiple automakers and a large number of turnkey suppliers.

Using our framework, we define Korea's production network as a unipolar, captive structure. We show that Korea's production network provided incentives for inertia that delayed the transition to EVs and consolidated Korea's position as a second-mover. We also show that despite lacking a domestic automaker, Spain's embeddedness in the EU's multipolar, modular production structure provided the space and incentives for turnkey suppliers to initiate and carry out novel innovation. These findings defy expectations about the centrality of domestic, legacy automakers in the transition to EVs (MacDuffie 2018; Schulze et al. 2015; Jacobides et al. 2016), at least when it comes to facilitating the transition from second-mover to novel innovation in NAEs.

The study is based on a two-level analysis. First, at the level of the value-chain, in line with the paper's meso-level approach, and second, at the level of the firm, to examine the impact of value-chain structures on novel innovation. The characterization of value chains is based primarily on secondary sources. The firm-level analysis is based on short cases of representative firms from each of the two countries. Research for the firm-level cases is based on data from public sources including annual company reports, published interviews with key stakeholders, podcasts, and articles from specialized publications. To interpret and complement the data, the paper relies on 25 semi-structured interviews with policymakers, scholars, legacy automakers, and managers of leading Korean and Spanish firms. Where suppliers are concerned, our purpose was to select firms that varied in terms of size, specialization, and degree of technology intensity so that they could represent the vast diversity of firms operating in the automotive sector in these countries. In the Spanish case, where many of the suppliers are SMEs, the selection of firms was informed by conversations with academic and industry experts working for the Spanish Government. Interviewees were recruited with the snowball method. The interviews were conducted in two waves: March–May 2019 and January 2023, capturing two moments before and after the 2020 tipping point toward EVs.

Our findings contribute to a broader literature on NAEs and semi-peripheral countries that underscores the constrains these types of countries face in a shifting global economy. The paper also speaks to scholars interested in understanding the way that "stacks" of national institutions, cross-national production structures, and firm-level features shape firms' innovation capacity. Finally, the paper may be of use

to scholars interested in the role of context (understood here to include institutions and production structures) in enabling firms to generate competitive advantages. The rest of the paper is structured as follows: the "Understanding Novel Innovation in NAEs" section develops the argument. The "The Framework in Action: Innovation in the Korean and Spanish Automotive Sectors" section showcases its explanatory power through an analysis of Korea's and Spain's transition to EVs. The "Conclusion" section summarizes and offers some final thoughts.

## Understanding Novel Innovation in NAEs

The transition from internal combustion engines to EVs involves changes in the set of feasible designs, technologies, skills, methods, priorities, and know-how that automotive firms rely on to define their strategies (Dosi 1983). Such changes destroy the competitive advantages of automakers and suppliers (Tushman and Anderson 1986), forcing them to develop new ones. To develop new advantages, automakers and suppliers need access to resources and capabilities that are valuable, rare, imperfectly imitable, and non-substitutable (Barney 1991; Barney and Clark 2007; Teece 2007). A firm's capacity to develop its stock of resources and capabilities depends on firm-level features such as size and ambidexterity (O'Reilly and Tushman 2016). However, in addition to firm-level elements, organizations need access to a broad range of exogenous resources and capabilities such as skills, research facilities, industrial standards, and infrastructures that are socially embedded and often country-specific (Rugman and Verbeke, 1992). Many of these are public goods that are undersupplied by markets and, therefore, need to be created by governments (Coyle 2020). This is where institutions come in. National institutional systems provide the organizational matrix for the provision of public goods (Polanyi 1944; Fligstein 2001; Ferguson 2013), but these systems admit different configurations that induce predictable patterns of firm behavior (Zysman 1994). For instance, Hall and Soskice (2001) distinguish between Liberal and Coordinated Market Economies, depending on whether coordination between economic actors is based on either market mechanisms or insider networks. However, the literature on varieties of capitalism tends to focus on a small subset of very advanced economies and has relatively little to say about NAEs. For instance, Hall and Gringerich (2009) refer to countries that do not fit the definitions of either a coordinated or liberal market economies as "Mixed Market Economies," a bag term that includes most semi-peripheral economies, including NAEs (Molina et al. 2007). The developmental state literature (Amsden 1998; Haggard 1990, 2018; Wade 1990; Weiss 1998; Thurbon 2016) partly overcomes this limitation by studying the transformation of Asian NAEs. Developmental state authors point out important features of East Asian institutional systems such as proactive states, competent bureaucracies and pilot agencies, linkages to business, and the capacity of the state to allocate funding that enabled them to become industrialized countries. Many of the conditions under which these systems operated prior to the 1990s, such as the presence of national barriers to trade, publicly controlled banking systems, or the capacity to create large numbers of middle-class jobs in mature manufacturing sectors have

since changed, making such models difficult to replicate now (Haggard 2018). Even if traditional developmental state models were viable, they were geared toward managing the risks of knowledge absorption and adaptation in mature industries for catch-up purposes. Managing the very high levels of technological, economic, and temporal uncertainty associated with novel innovation in countries that have already reached the efficiency frontier requires a qualitatively different type of system (Wong 2011). The institutional perspective has a second limitation: it focuses exclusively on national institutions. Firms need access to resources and capabilities from domestic institutions to innovate, but they also gain access to skills, assets, and incentives from the global production networks within which they operate. Therefore, to understand the patters of innovation of legacy automakers and suppliers, we also need to explore the contribution of global production networks. We turn to this in the next sub-section.

### A Meso-Level Perspective on Innovation

Firms do not operate autonomously. The automotive industry, like many complex manufacturing sectors, is organized around global production networks. These networks are geographically dispersed multi-firm structures composed of lead firms and suppliers (Coe and Yeung 2015). Automakers operate as lead firms thanks to their roles in design, assembly coordination, distribution, and regulatory compliance. Suppliers of parts and components produce for the lead firms (Jacobides et al. 2016; Luo et al. 2012).

Not all production networks are structured the same (Womak et al. 2007). Regional variations in the structure of production networks can have a significant impact on firms' incentives to innovate, the types of innovation they engage in, and their degree of autonomy to initiate innovation. We build on the literatures of value-chain governance and innovation to identify three interrelated aspects of global production networks that have a bearing on innovation: the position of the firm within the network, the number of lead firms, and the types of links that bind lead firms and suppliers.

#### Position of Firms in Global Production Networks

Lead firms within production networks coordinate the operations of the entire network, determine who is included in it or not and under what terms, allocate responsibilities for when, where, and by whom value is created, and capture the largest share of value (Gereffi, 1994; Gibbon and Ponte 2005; Kaplinsky 2005; Dallas et al. 2019). Suppliers develop sophisticated parts and components and integrate them into complex systems that feed into the final output. They produce for the lead firms (Jacobides et al. 2016; Luo et al. 2012).

The division of labor between automakers and suppliers affects the type of innovation each type of firm pursues. Automakers' central role in the design of vehicles and their responsibility for coordinating the entire delivery network enables them to undertake innovation that involves changes to the vehicle as a whole. Suppliers'

specialization enables them to undertake innovation that involves changes to vehicles in their underlying components and production processes (Marples 1961). Because of its scope, novel innovation regarding the vehicle as a whole involves higher levels of technological, economic, and temporal uncertainty and higher costs than innovation regarding the vehicle in its components. Such differential makes automakers less likely to break preexisting patterns as second-movers and engage in novel innovation compared to suppliers.

### The Number of Lead Firms in a Global Production Network

At its most basic, a production network is composed of a single, market-dominant lead firm and a network of suppliers (unipolar networks). However, a global production network may include two or more lead firms that vary in size and degree of market power (multipolar networks) (Ponte and Sturgeon 2014). Well-established, market-dominant lead firms in unipolar networks have few incentives to become first-mover innovators since they face little immediate competition in their domestic markets from other lead firms[4]. In addition, the effort initially has only a small positive impact on their markets yet requires overcoming organizational path dependencies (Christiansen 1997). The lack of external and internal incentives is compounded by a reluctance of unipolar lead firms to develop alliances with other lead firms for the purposes of managing the uncertainties of novel innovation. This is because such alliances can undermine the autonomy and the position of power of unipolar lead firms (Ravenhill 2001). The combination of high uncertainty, low initial incentives to innovate, and reluctance to use mechanisms such as alliances to defray uncertainty means that lead firms in unipolar networks face significant obstacles to switching from second-movers to novel innovators.

By contrast, the presence of multiple automakers vying for maker power in multipolar production networks generates incentives to innovate and lowers the barriers of shifting to novel innovation. The constant struggle for market share in the domestic market incentivizes lead firms to develop novel innovation to stay ahead of the competition and to prevent falling behind. In addition, the presence of multiple lead firms, especially when the distribution of market power among them is relatively balanced and no firm has access to a full range of resources and capabilities, creates incentives for pre-competitive cooperation between lead firms or between them and potential new entrants. Such cooperative arrangements help diffuse the uncertainties and the costs associated with novel innovation and facilitate the acquisition of needed resources and capabilities, thereby lowering a major barrier to novel innovation. Accordingly, we expect lead firms in multipolar networks to be more likely to shift from second-movers to novel innovators than those in unipolar networks.

[4] This is not to say that a lead firm will not face competition on a global level. However, in value chains that are fragmented by geography, as is often the case in the automotive sector, the absence of other lead firms within that value chain will likely dampen direct competition within the domestic market.

### Links Between Lead Firms and Suppliers

The relational character of interfirm relationships within global production networks leaves space for variance in the way that such connections are governed. Gereffi et al. (2005) characterize five analytical forms of coordination: hierarchical, captive, modular, relational, and market-coordinated, based on the differential of power between the lead firm and the suppliers. We simplify this structure to focus only on two types of coordination: captive and modular, which we consider to be the most common empirical varieties of coordination. Captive structures are characterized by the presence of suppliers that are heavily dependent on and controlled by a lead firm. Modular structures are characterized by the presence of independent or turnkey suppliers that are fully accountable for process technology and can adapt their equipment to serve the needs of multiple lead firms.

We posit that captive structures constrain the autonomy of suppliers to initiate and carry out innovation that is not applied and/or incremental because there is no guarantee that the innovation will be accepted by the lead firm they depend on. Lacking a broader portfolio of clients to which they can pitch and potentially sell their innovation ideas, suppliers depend on their lead firm to initiate demand for new solutions. Captive suppliers in a unipolar network are particularly constraint: not only are they dependent on the lead firm to initiate and carry out innovation but also the lead firm has limited incentives to request or accept innovation since it faces little competition within its value chain.

By contrast, the independent nature of automotive suppliers in modular structures facilitates innovation via three mechanisms. First, having a broader portfolio of clients gives suppliers the autonomy to take the initiative on innovation, likely increasing the instances of early innovation. Second, it creates interdependencies between automakers and suppliers that lead to joint innovation, enabling suppliers to enter new segments of the industry. Third, the presence of autonomous, turnkey suppliers translates into an increase in the sheer number of firms taking the initiative in creating new knowledge in different points within the production network. The result is an increase in the lines of inquiry pursued and the density of innovation efforts, which raises the odds of success.

## The Framework in Action: Innovation in the Korean and Spanish Automotive Sectors

We illustrate the value of our framework through empirical examples of innovation patterns in the Korean and Spanish automotive sectors. Each country represents a type of production network: unipolar, captive (Korea) and multipolar, modular (Spain). The section is divided into two parallel subsections, one for each type of production structure. In turn, each subsection is divided into two parts. The first characterizes the structure of the production network. The second discusses its innovation pattern as firms transition to EVs.

## Innovation in a Unipolar, Captive Production Network: Korea's Transition to EVs

### Characterizing Korea's Unipolar, Captive Network

Korea epitomizes the concept of a unipolar, captive network. HMC, Hyundai Motor Company, the world's third largest automaker, accounts for 87% of Korea's vehicle production (KAICA 2023). In turn, HMC is the central component of the Hyundai Motor Group (HMG), which accounts for most of Korea's automotive production network. Four of Korea's six largest suppliers are HMG affiliates (Hyundai Mobis, Hyundai Wia, Hyundai Transys, and Hyundai Kefico) (Berylls 2021; Automotive News 2019). The remaining two (Hanon and Mando) belong to HL (formerly the Halla Group) a business group originally established as the Hyundai International Group. Although HL is formally separate from Hyundai, the group is led by Chung Mong-Won, a first cousin of Chung Mong-Koo, who was HMG's Chairman until his son took over in 2020. HMG's reach extends beyond parts and components to encompass most of the Korean automotive production and distribution network through 29 affiliates in financial services, steel, machine tools, engineering, logistics, rolling stock, and IT services (Hyundai Motor Group 2023a).

Large Korean suppliers are heavily controlled by and dependent on HMC. Control is exercised via circular shareholdings, board memberships, and procurement. Hyundai Mobis, the world's seventh largest suppliers and by far Korea's largest supplier (Beryll's 2021) epitomizes these practices. In 2023, Kia Motors, one of HMC's brands, was Mobis' largest shareholder with a 17.24 stake. Together, Chung Mong-koo and Hyundai Steel owned an additional 13.0 stake in Mobis (MarketScreener 2023a). In turn, Mobis was HMG's largest shareholder with a 21.6 stake (MarketScreener 2023b). Mobis also held sizeable stakes in three additional Hyundai affiliates (MarketScreener 2023a). In addition to these cross-shareholdings, HMC exerts direct managerial control over Mobis. Since 2020, HMC and Mobis have been led by the same person, Chung Eui-sun. Finally, Mobis is functionally dependent on HMC: the supplier obtains 90% of its business from the automaker (JustAuto 2023). The pattern described above is not unique to Mobis. For instance, in 2023, HMC and Kia Motors (a second automaker brand in the Hyundai family) owned 38.7% of Hyundai Wia (MarketScreener 2023c), 81.56% of Hyundai Transys (Hyundai Transys 2023), and 100% of Hyundai Kefico (Marklines 2023). In general, large Tier 1 suppliers have found it difficult to diversify their client portfolio to elude captivity. Until 2010, HMC disapproved of client diversification and could go as far as withdrawing its supplier certification, a prerequisite to serve the automaker (Greimel 2016). Since then, diversification has increased, in part to compensate for HMC's global sales drop in the second half of the 2010s (Greimel 2016; Jin and Lee 2020). Nonetheless, with few exceptions, large Korean suppliers remain captive. In 2018, 80% of sales by Korea's Tier 1 suppliers came from the Hyundai Motor Group (Yamada 2019).

### Innovation in Korea's Unipolar, Captive Network

As expected in our framework, HMC's uncontested market position within its production network and the self-involved nature of the Korean network delayed the launch of a new EV platform. The delay had a direct negative impact on the automaker's sales and market position in key markets. A late entry into EVs also affected its network of dependent suppliers, consolidating Korea's position as a second-mover.

HMC's first EVs were launched in late 2018, 21 years after the launch of the first Prius model and 6 years after the introduction of Tesla's Model S. Even then, the Korean vehicles were adapted versions of preexisting internal combustion engine models rather than new EV models. HMC did not launch a dedicated EV platform until 2021 (Song 2020; Herh 2023). To offset its late entry into EVs and carve a competitive niche, HMC has set its sights on fuel-cell EVs (FCEVs) (Harris and Song 2018; Yoon 2023). If successful, HMC's foray into FCEVs would constitute a shift to first-mover innovation, but this is not given. In fact, as expected in our framework, HMC has been reluctant to forge strategic alliances with other automakers to share the costs and the technological, economic, and temporal uncertainties involved in the development of FCEVs. Aware of the potential risks, in 2019 HMC announced its willingness to sell its fuel-cell technology to other automakers to reach critical mass (White et al. 2019). Yet, this strategy still requires HMC to bear the full costs of technological development, estimated to be around $280 billion (White et al. 2019), or roughly the size of HMC's market capitalization (Bloomberg 2023). To avoid diluting its market power through a partnership with another automaker, HMC is relying instead on support from the Korean government. The 2020, Korean Style New Deal makes the development of hydrogen infrastructure and domestic FCEV vehicles a central part of its strategy and identifies a partnership with HMC as the means to achieve this objective (Strangarone 2021; Wang 2022; IEA 2021).

HMC's delay in entering the EV segment has not led to failure. Since the launch of its Electric Global Modular Platform in 2021, HMC has become the sixth largest EV automaker (Herh 2023). However, the delay led to a production decline between 2016 and 2020 (OICA 2023) and has affected HMC's standing in the USA and China, two critical markets. The US' 2022 Inflation Reduction Act offers tax credits to purchasers of EVs manufactured in North America through 2025. Since Hyundai only committed to building an EV production plant in the US in 2022, the plant will not come online until 2025 and HMC, unlike its rivals, will not benefit from the IRA's credit to expand its market share (Yonhap News 2023; Yang and Klayman 2022). A slow transition to EVs has also led to a decline in sales in China (Global Times 2022). The rise of Chinese brands and the consolidation of Tesla and Volkswagen in the Chinese market will make it difficult for Korean firms to regain ground in the world's largest market.

The impact of HMC's transition to EVs has important implications for captive suppliers. The automaker's lackluster performance between 2016 and 2020 forced the government to approve a $3 billion funding plan in 2018 to address suppliers' liquidity problems (Kim 2018; Jung and Jung 2020). Even the largest suppliers were

affected. HMC's closing of an assembly plant in China in 2019 triggered the closure of the Mobis plant that served it (Jung 2019) and led to a round of layoffs at Mando (Nam 2019). These developments affected suppliers' innovation capacity. A survey conducted by Korea Automobile Manufacturers Association among 300 suppliers in 2021 found that only 17.7% of them were adjusting to the EV transition, citing lack of financial capacity as one of the main causes (Pulse 2021). As in the case of the automaker, this situation does not necessarily spell disaster for suppliers affiliated with HMC. Cross-ownership patterns between HMC and its suppliers can provide access to capital for innovation. However, the urgency of ramping up vehicle production after a late entry into EVs has forced suppliers to resort to acquisitions and controlling alliances with novel innovators rather than organic innovation, a strategy that reinforces their position as second-movers. For instance, to develop a state-of-the-art lidar[5] advanced driver-assistance system, Mobis has established an alliance with Velodyne Lidar, a Silicon Valley firm (Velodine Lidar 2019). Similarly, to bolster its capacity in electronics engineering, Hanon Systems has acquired a specialized division from Magda (Hanon Systems 2018).

## Innovation in a Multipolar, Modular, Production Network: Spain's Transition to EVs

### Characterizing Spain's Production Within Europe's Multipolar, Modular Network

The decision to launch the EU single market in 1986 led to the development of an EU-wide automotive sector characterized by the presence of multiple automakers and a large number of turnkey suppliers based across multiple EU countries. Specifically, the EU production network is composed of four of the world's ten largest automakers (Volkswagen, Renault, Fiat, and Stellantis) and several mid-sized and small independent automakers, including Daimler, BMW, and Ferrari (OICA 2023). The EU is also home to 23 of the world's 100 largest suppliers (Automotive News 2019) and several thousand smaller suppliers. Many of these are turnkey suppliers that serve multiple automakers and are not controlled by them.

Spain is a significant actor in the EU automotive sector. With a production capacity of over three million vehicles, Spain is the second largest vehicle manufacturer in Europe after Germany, and the world's 9th largest auto producer (OICA 2023). Spain's production is fully integrated within the EU-wide structure. In 2021, 87% of Spanish vehicle production was exported, three quarters of which to Europe (ANFAC 2022). Two particular features define Spain's production structure and showcase its integration within Europe: the lack of a domestic automaker and the presence of a potent, globally competitive supplier industry. Local assembly production consists of 17 production plants owned by 9 foreign automakers (ANFAC 2022). The supplier industry comprises about 1,000 firms (Montoriol Garriga and Diaz 2021). Over half of these are foreign invested firms (Guillén 2010), but Spain

[5] Laser Imaging Detection and Ranging is a technology that uses pulsed laser to create 3D mapping of its surroundings including other vehicles to facilitate navigation.

is also home to a healthy population of domestic suppliers, including three of the world's largest independent suppliers: Gestamp, Grupo Antolin, and CIE Automotive (Automotive News 2019; Berylls 2021).

### Innovation in a Multipolar, Modular Network

The absence of a domestic automaker means that innovation in Spain revolves entirely around systems and components. As expected by our framework, the EU's modular production structure has provided substantial opportunities for large, established turnkey suppliers to initiate, carry out, and capture value from innovation, including novel innovation.

Opportunities for innovation for Spanish suppliers have derived mainly from the ability of suppliers to build and leverage partnerships with legacy automakers, other suppliers, and new lead firms. Spanish firms have used these partnerships to enter new higher value-added segments, transform traditional products into innovative ones, and offer specialized services. We illustrate these ideas through the analysis of three firms: Gestamp, Ficosa, and IDIADA. These firms showcase the variety of Spanish suppliers operating within the EU's modular value chain in terms of size, specialization, and strategies. The trajectories of these firms underscore the idea that value generation and value capture from innovation can and does take place in different points within a given production network, including traditionally low-tech segments and services.

### Innovating Through Codesign: Gestamp

Gestamp is Spain's largest automotive supplier and the world's 24th largest automotive supplier (Automotive News 2019; Berylls 2021). Gestamp is an independent supplier; it is controlled by the Riveras family, which owns 74% of the firm through a holding company (EuropaPress 2023). The company is a leader in the production of metal structures (chassis, body in white) and automotive metal components such as axels.

Gestamp has capitalized on its relationships with multiple automakers within the EU-wide production network to enter new and higher value-added segments through codesign. The much heavier weight of EV batteries has compelled automakers to request lighter metal structures that can stand stringent crash, performance, deformation, and energy absorption tests (Gestamp 2017). Within the EU's modular structure, automakers have been willing to outsource the design and development of these core structures directly to trusted Tier 1 suppliers. To take advantage of the opportunity, Gestamp developed a wide range of additional in-house capabilities including die/tool manufacturing capabilities, several types of forming capabilities, advanced assembly capabilities such as remote laser welding, and advanced finishing technologies such as powder coating and cataphoretic painting (Gestamp 2017). These capabilities enabled Gestamp to enter new business segments such as skins (the external, most complex part of a car's metal structure), which the firm now offers to multiple automakers. In addition, in 2010, Gestamp became one of the first companies to invest in hot stamping, a technology that delivers high-strength

and ultra-light steel products. Through the acquisition of SSAB HardTech, Edscha, and TyssenKrupp Metal forming, Gestamp acquired world-class capabilities in hot stamping, which, combined with proprietary validation, prototyping, and crash capabilities, enabled the company to develop novel vehicle chassis structures that improve crash standards and offer them to Honda and Volkswagen (Martin 2021a).

Gestamp's combination of internal and external capabilities and resources has resulted in a significant increase in codesigned projects in the past decade. In 2010, Gestamp was engaged in only four co-development projects. By 2015, the number surpassed 150, and by 2021 Gestamp had completed more than 300 codesigned projects (Martin 2021b). The increase has enabled Gestamp to gain scale in Europe, the USA, and Asia and to diversify its client portfolio (Murphy 2017; Riveras 2021). Between 2007 and 2017, the year Gestamp launched its partial IPO, the company's revenue more than doubled (Gestamp 2017). Between 2017 and 2021, Gestamp has continued to expand, building 17 new production plants (Riveras 2021).

#### Innovation Through Partnerships: Ficosa

Ficosa was founded in 1949 by two friends who set up a workshop that produced rearview mirrors and mechanical cables for the aftersales market (Guillén 2010). Yet, since 2010, Ficosa has transformed into a global leader in smart vision systems, advanced driver-assistance systems, and cutting-edge battery components, introducing several novel products that enable the company to remain relevant in a world of electric and autonomous vehicles. Ficosa's success in transforming from a provider of low-tech automotive parts to a sophisticated innovator in electronic systems stems from its ability to leverage relationships with multiple automakers and suppliers within the EU's value chain.

Ficosa has a long history of leveraging its network to generate value. As the EU-wide production network came into being in the 1980s, Ficosa built on its preexisting relationships with foreign automakers established in Spain to expand its operations across Europe. From the late 1990s, Ficosa used this experience building and managing relationships with multiple automakers to diversify its client portfolio and expand into the USA, Latin America, and Asia, (Ficosa 2023). Since the 2010s, the company has pivoted from using its client network to expand geographically to using it for the purpose of transformation and innovation in electronic systems. Coming from a low-tech segment (rearview mirrors), the first step to achieve this transformation was to develop in-house capabilities in electronics. To do so, Ficosa acquired Sony's manufacturing and engineering assets in Barcelona in 2010 and developed a strategic partnership with Panasonic in 2015. The company then approached Volkswagen, its largest client, to propose the codesign of the world's first digital rearview system (Ficosa 2018). With a novel product in hand, in 2019, Ficosa signed a contract for the development of a rearview mirror with electronic toll collection for the BMW X5, which it then offered to other automakers (Interview Ficosa). Ficosa's approach proved to be highly successful: between 2019 and 2021, sales of its rearview cameras trebled, reaching 6 million (Ficosa 2021a). By then, Ficosa had integrated its original system into a Surround View System and expanded into other segments that require smart vision such as camera-based advanced driver-assistance

systems to further develop and consolidate its advantage (Ficosa 2021a; Ficosa 2021b).

In the 2020s, the company has continued to build on these experiences to develop other novel product lines. In particular, Ficosa has continued to rely on collaborative partnerships with other suppliers from across Europe. Some of those collaboration include the participation of European research centers and funding from the EU's flagship Horizon Europe program. For instance, project MARBEL, launched in 2021, involves a 12-partner research consortium with firms from seven European countries. Project MARBEL aims to design, develop, and demonstrate novel high-performance battery packs and robust battery management systems for EVs. (MARBEL 2023). Through this partnership, Ficosa has developed a novel electric module that enables motor vehicles to connect to electric chargers via Wifi and a high-capacity aluminum connection box that enables ultrafast battery charges (Ficosa 2023b). As in the case of Gestamp, Ficosa's success is reflected in its results. In 2022, the company's revenue was slightly below €1 billion (Ficosa 2022).

#### Innovating in Specialized Services: Applus+IDIADA

IDIADA (Institute for Applied Automotive Research) has a long trajectory of innovation. The organization was established in 1971 at the Polytechnic University of Catalonia. Its original role, at a time when the Spanish automotive sector was taking off, was to absorb and adapt innovation to conditions in the domestic market (Garcia Ruiz 2001). In 1999, IDIADA was established as an independent company controlled by Applus+, a domestic industrial group. Applus + IDIADA has since become a global leader in automotive and industrial testing, inspection, and certification (Applus + 2023a; Applus + 2023b; MarketScreener and Applus Services 2023e). In 2022, it generated over €2 billion in revenue (Applus+, 2023c).

Like other Spanish suppliers, Applus + IDIADA (henceforth, IDIADA) leverages the modular nature of Europe's value chain to provide innovative services for a broadening portfolio of clients. IDIADA benefited from the launch of a large number of new EV models and automakers' willingness to outsource specialized functions to experienced suppliers. The entry of new players such as Tesla and Google, which lacked previous experience in the production of motor vehicles, generated additional demand for design and testing services. Suppliers developing new EV components (battery packs, charging systems, engines, auxiliary systems) have also increased demand for design, verification, product validation, and certification for each of these individual elements and for whole systems.

IDIADA has taken advantage of these opportunities by acquiring new resources and capabilities in areas such as electronics, cybersecurity, and aerodynamics. IDIADA took the initiative to get involved in the design, development, and homologation of EVs in 2002, and it pursued a strategy that combines inorganic growth, organic growth, and alliances. In 2022 alone, the company acquired five companies in the areas of cybersecurity, industrial metrology, technical vehicle inspections, and IT product certifications for a value of €66 million. Simultaneously, IDIADA spent another €66 million on in-house facilities, including new testing and modeling facilities in Europe and China (Applus + 2023d).

Like Ficosa, IDIADA has relied heavily on partnerships with other turnkey suppliers from across the EU and with European research centers such as the German Fraunhofen Institute and the Spanish Centre for the Development of Industrial Technology to share the costs and uncertainties related to novel innovation. Since 2012, the company has led or participated in 75 novel innovation projects (Addplus + IDIADA 2023e). As in the case of Ficosa, several of these projects are funded by the Horizon Europe program. Since 2019 alone, IDIADA has been part of 22 such projects (Addplus + IDIADA 2023e). The high number of projects showcases IDIADA's innovative profile. As in the case of Gestamp and Ficosa, the results are eloquent: between 2011 and 2018, IDIADA's revenue increased by 42% (Applus + annual reports, 2012 and 2019). Between 2021 and 2022, and in a context of falling automotive production, revenue still increased by 15% (Applus + 2023c).

Overall, the trajectories of Gestamp, Ficosa, and IDIADA showcase the range of opportunities afforded by the EU's multipolar, modular structure for turnkey suppliers and the autonomy such suppliers have to take the initiative and leverage their relationships with multiple firms in the network to generate innovation. Although not all the innovation that Spanish suppliers have engaged in is novel innovation, these cases show that, despite the absence of a domestic lead firm, at least some of the largest firms have managed to overcome Spain's traditional stance as a second-mover.

## Conclusion

At a time when the automotive sector is shifting to EVs, firms need to generate innovation to remain competitive. Firms from New Advanced Economies, especially those based in countries that have large legacy automotive sectors such as South Korea and Spain, face this challenge from an especially disadvantaged position. Unlike the institutional systems of world-leading economies, those of NAEs are not geared toward managing the high levels of technological, economic, and temporal uncertainty associated with novel innovation. Furthermore, unlike new entrants from emerging countries, NAE firms cannot compete on costs and contend with obstacles in the form of large sunk investments in physical infrastructure and organizations. In this context, we asked under what conditions are firms more likely to shift from second-movers to novel innovators.

After pointing out the limitations of micro- and macro-level explanations, the paper adopted a meso-level perspective that focused on the characteristics of global production networks. We argued that a firm's ability to shift from second-mover to novel innovator could be gauged by looking at three aspects of the production network within which it operates: the position of the firm within the network, the number of lead firms, and the types of links that connect lead firms and suppliers. Lead firms face generally higher obstacles to novel innovation than suppliers due to the much greater uncertainty and costs involved in generating innovation regarding changes to the product as a whole rather than the product in its components. Market-dominant lead firms in unipolar structures have fewer incentives and face more barriers to switch to novel innovation than their counterparts in multipolar, modular structures, because they do not face an

immediate domestic market threat, and they are less likely to engage in alliances with other lead firms to diffuse the uncertainties and the costs of novel innovation. Finally, captive suppliers, especially those operating in unipolar structures, have less autonomy to initiate and carry out novel innovation than turnkey suppliers in modular networks.

We illustrated our argument through the examples of South Korea's and Spain's automotive sectors. We characterized Korea's production network as a unipolar, captive structure and showed that Spain's automotive sector is deeply embedded in the EU-wide multipolar, modular structure. As expected, the presence of a single, market-dominant automaker that controls a vast supply network in Korea was associated with a delay in entering the EV segment and the reinforcement of pre-established patterns of second-mover innovation. The delay in transitioning to EVs did not drive the Korean automaker out of the market, but it translated into lost business opportunities in two key markets, the USA and China, where it will be difficult to recover lost ground. By contrast, our analysis showed that, despite the lack of a domestic automaker, Spain's embeddedness in the EU's multipolar, modular structure has provided multiple early entry points into the EV segment for Spanish independent suppliers. Often, novel innovation has emerged through codesign or cooperation with other firms within the EU-wide network, including other suppliers.

Our analysis shows that, although semi-peripheral economies may face industrial transformation from a disadvantageous position, firms based in these countries can and do find ways to create positions of power and competitive advantage by leveraging meso-level aspects of the production structures within which they operate. The paper complements the institutionalist literature by going beyond national institutions, showcasing some of the particularities of NAE countries when it comes to novel innovation, and by examining the limitations and affordances derived from complex production structures.

The paper's research design leaves important questions open. The qualitative nature of the analysis makes it difficult to assess which proportion of the industry has shifted toward novel innovation. Future analyses should aim to quantify this impact. The focus on the automotive industry also raises question as to whether our framework can be generalized to other industries and other NAEs. Both quantifying the ability of firms to shift to novel innovation and further comparisons across industries would help strengthen the paper's claims and determine whether the conditions discussed in this paper reach the level of necessity/sufficiency. It is worth noting that existing analyses of modular industries such as semiconductors suggest that the relationship between value-chain modularity and novel innovation applies more broadly. Nonetheless, NAEs rarely feature in such studies.

More generally, the Hyundai Motor Company's difficulties in transitioning from fast follower to novel innovator pose questions about the economic prospects of New Advanced Economies. After decades of successful transformation and industrial upgrading, can NAEs truly overcome the gap that still distinguishes them from the most advanced economies if their lead firms are unable to generate novel innovation? Can they continue to thrive as second-movers in industries that are being redefined? For NAE countries that are heavily dependent on foreign direct investment and transnational exchanges such as Spain, other questions also arise. Paramount among these is whether they will continue to attract the large amounts of inward foreign direct investment they depend on.

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