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The Chinese race for innovation and its state-driven safety car:

A new Developmental State paradigm in the automotive industry

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What we cannot speak about we must pass over in silence.

Ludwig Wittgenstein in Tractatus Logico-Philosophicus

Abstract

The electric vehicles are increasing in popularity year by year. However, the market demand for such technology is still moderate and most traditional actors within the automotive industry are having a hard time adapting to this new stage. What poses threats to the survival of some actors can simultaneously become a great opportunity for the emergence of new major players. This paper looked at the Chinese innovation process and mapped out the important actors and dynamics entailed by it. The main preoccupations that the present research engaged with are whether the new energy vehicle (NEV) sector comes with a paradigm shift for the Chinese industrial environment, what is the role played by the state in this new context, and lastly, whether there are any differences between the state-owned enterprises' innovation networks and those formed around the private actors. The thesis brought into discussion a new variant of the Developmental State Model drawing upon the structure provided by the Triple Helix theory. The state is not simply designing and imposing industrial plans anymore, but it becomes a manager of the frontier technology innovation networks, using the market dynamics as an optimisation tool.

Keywords: new energy vehicle, automotive industry, Developmental State, Triple Helix Model, China, state-led innovation

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Acronyms and vocabulary

BAIC	Beijing Automotive Industry Corporation
BEV	battery electric vehicle
BMS	battery management system
BYD	Chinese company also known as "Build Your Dreams"
CAS	Chinese Academy of Sciences
CKD	complete knocked-down kit
ECA	ethnographic content analysis
FAW	First Automobile Works
FCEV	fuel cell electric vehicle
FGP	Flying Geese Paradigm
FYP	Five-Year Plan
GAIC	Guangzhou Automobile Industry Corporation
HEV	hybrid electric vehicle
ICEV	internal combustion engine vehicle
IoT	Internet of Things (technology describing a network created between multiple devices, which is also used in smart cars to facilitate the development of self-driving and artificial intelligence-controlled vehicles)
JV	joint venture
NDRC	National Development and Reform Commission
NEV	new energy vehicle
NEVS	National Electric Vehicle Sweden
NPC	National People's Congress
PHEV	plug-in hybrid electric vehicle
PRC	People's Republic of China
PSA	Peugeot Société Anonyme (French manufacturer of Peugeot, Citroën, and Opel)
R&D	research and development
SAIC	Shanghai Automotive Industry Corporation
SAW	Second Automobile Works (later becoming Dongfeng)
SGCC	State Grid Corporation of China
SNA	social network analysis
SOE	state-owned enterprise
TVTC	Thousands of Vehicles, Tens of Cities (the first NEV pilot program conducted by the Chinese government)
V2G	Vehicle to Grid (a charging technology that uses personal cars as energy storage batteries)
VW	Volkswagen
WTO	World Trade Organisation

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1. Introduction

On the 11th of October 2006, the National People's Congress was publishing China's 11th Five-Year Plan. For the first time, it was comprehensively stated within the industrial plan's points the governmental intention to focus on the development of what will be called from now on *new energy vehicles* – that is plug-in hybrid electric vehicles, pure electric vehicles and fuel cell automobile technologies. The strategy encouraged research and development and large-scale demonstration projects within this emerging sector (Gong, Wang and Wang, 2013, p. 211).

The automotive industry has been, for the last century, arguably one of the most important economic sectors in the world. It has been visibly supporting the economic performance of various Western countries such as the United States of America and Germany, while also being foundational for the industrial development of Eastern countries such as Japan, South Korea, and China (Dmytriiev et al., 2019; Green, 1992; Sturgeon and Biesebroeck, 2011). This aspect can be explained through a few arguments. Firstly, the nucleus of the automotive industry, by nature, supports multiple related industries and business sectors. Some examples in this respect are mining, steel and electronics upstream, and finance, insurance and fuel supply downstream (Mathur and Kidambi, 2013). Practically, a well performing automotive industry can have great spill-over effects throughout many other areas of the economy. Secondly, the access to this industry is very limited, given that it is costly, knowledge intensive and highly dependent on the performance of other industries specialised in raw materials. Such great risks transform the industrial environment of this sector into one characterised by oligopoly, where only a few big actors impose themselves on the market, while others are rather marginal (Humphrey and Memedovic, 2003, p. 2). Lastly, even though the automotive industry is regarded as global, it is in many cases operated regionally or locally. From a political point of view, the high cost and visibility of the automotive products among the population can spark political backlash if most of these are imported (Sturgeon and Biesebroeck, 2011, p. 185).

This massive pillar industry is presently undergoing major changes in the light of environmental sustainability and technologic advancement, leading to important shifts of influence on the global market and within the related production chains. These changes have been triggered by the popularisation of alternative energy vehicles such as battery electric

vehicles and plug-in hybrid electric vehicles. The main reason behind this phenomenon could be essentialised through two words: range and price. These are the two main concerns of the average potential alternative energy vehicle buyer (Coren, 2019). Consequently, the range and price of an electric vehicle are directly linked to the battery and its related systems (Coffin and Horowitz, 2018). Practically, the battery pack replaces in function and importance the outdated internal combustion engine, marking the start of a new race in the automotive industry where the battery pack supplier could become more relevant than the manufacturer itself. Accordingly, this was the perfect opportunity for new countries like China to finally have a real chance in competing on the global automotive scene. The new energy vehicle sector upgrades the whole idea of automotive industry by bringing it at the rank of frontier technology. This paper will attempt to explain and analyse the dynamics behind the Chinese innovation of alternative energy vehicles, precisely in the context of a technological frontier setting.

All the aforementioned aspects feed into the arguments that stood behind the choice of the automotive industry as focus for the present research project. The automotive industry is just an exponent of the system. The conclusions that will be drawn in this paper are not limited to this specific industry. They will highlight patterns that can be extrapolated to the overall reality of the Chinese context. That is, the Chinese approach towards the automotive industry unveils how the role of the state can be reinvented in a different direction than the one proposed by the orthodox economic narrative. The policy maker is not only a regulator and an investor in the context of technological frontier, but it is also a manager and mediator between the scientist and the businessman. Furthermore, the performance of the New Developmental State is no longer measured in economic growth, but in innovation output. As a consequence, the general focus moves beyond production capacity and market demand, towards R&D capacity. The state still creates the ideal environment for innovation by facilitating the interactions between SOEs, universities, private actors, and foreign actors through the traditional tools of the developmental state (i.e. initiatives, regulations and incentives). But more importantly, the state has acquired a new tool that makes possible the development of frontier technologies, namely the market. The market is part of the state-managed industrial environment. It is carefully handled and specifically injected by the state in areas deemed as inefficient in order to compensate for the weaknesses of the centralised economic model.

As starting point, it is be vital to understand the Chinese context prior to the appearance of this set of new trends. Thus, I will provide in the following subsection a brief historical background, so that the overall aims of this research project can be easily grasped.

1.1. Background

During the Maoist era, the Chinese automotive industry is almost inexistent. The only few technologies available are reminiscences from the Japanese colonial era and imported knowledge from the Soviet Union. Even though under Mao there are founded the first manufacturing plants, First Automobile Works and Second Automobile Works, the production is majorly focused on trucks and other types of commercial vehicles, the only exceptions being the Hongqi cars that the country's political elite used and the few taxi fleets available at that time (Anderson, 2012, pp. 53-55). The real starting point of the Chinese automotive industry is marked by Deng Xiaoping's opening up reforms, offering therefore the prospect of integration into the globalising economy (Feng, 2018, p. 2). The guiding mantra of the 1980s was "learning from the West" (Anderson, 2012, p. 56), meaning that the state-owned enterprises would lunge at foreign automakers to establish join ventures as a strategy of industrial upgrade (Feng, 2018, pp. 4-5). The idea behind this approach is that the SOEs would offer the foreign manufacturers the Chinese market in exchange for technology. Nonetheless, this plan was proved to be inefficient, given that the local parts suppliers were underdeveloped for the foreign standards. Consequently, the Chinese joint ventures were faced with having to assemble complete knocked down kits (Chang, 2011, pp. 28-29), thus limiting a lot the amount of technology that was transferred. The dynamic within the domestic automotive industry changed one more time during the late 1990s and early 2000s together with the Chinese accession to the World Trade Organisation. Found in the position of an underperforming industrial upgrade strategy that was now forbidden under the WTO regulations, the government starts promoting the idea of JV indigenous brands in exchange for production capacity expenditure approvals, on one hand, and autochthonous innovation on the other hand (Mitchell, 2014).

According to Anderson (2012, p. 61), from a Chinese perspective, innovation in the ICEV sector did not imply reinventing the wheel, but just making a slightly improved product compared to their foreign counterparts. This can be explained through the fact that the foreign automakers were already having a strong hold of the ICEV-related technologies, with not much room left for improvement besides minor tweaks in the engine's performance. The Chinese automotive industry has joined the ICEV race too late to have any realistic chances of getting onto the podium. The officials are fully aware of this aspect and the adopted policies are trying to compensate the inherent handicap. The state has played a central role throughout the industrial development of the automotive sector, fulfilling the roles of manager, planner,

regulator, and investor. This can be specifically seen through the Five-Year Plans and the fact that until the late 1990s, all domestic actors in this sector were state-owned (Feng, 2018, p. 35). Under this mindset, the NEV trend is perceived as a fresh start for the automotive industry. The Chinese can finally compete on level grounds with the foreign manufacturers, given that the technological knowledge is supposedly at the same level, regardless of the ICEV past performance. Furthermore, the NEV sector is an ideal ground to demonstrate the state's vital role at the frontier technology innovation level.

1.2. Research question

This paper will attempt to assess and analyse the position of the Chinese automotive industry in this new race by means of innovation, market and policies, while taking into account the state and its related entities, the domestic private actors and the foreign actors. In this respect, the research will have one principal question from which other two secondary questions will derive with the aim of augmenting the answer to the principal question. The main question is: *did the NEV trend trigger a paradigm shift in the Chinese auto industry, compared with the ICEV era, thus transporting its industrial context to a new phase?* And the two sub questions are: *do the central and local governments play a new role in this peculiar phase?* and *are there structural differences between the private sphere and the governmental sphere when it comes to their innovation networks?* The main assumptions of this thesis are that first of all, the Chinese automotive industry has entered an innovation-driven stage once the governmental focus has been placed on the development of NEV technology. And secondly, the state's role in this new stage has changed from the past, revealing a new type of the developmental state which is also the ideal manager of innovation at the technological frontier.

1.3. Academic contribution

The literature covering the political economy of the NEV phenomenon in China is still limited, usually remaining at a level of niche journalism or consultancy firm report. It is true that the context might still be young, so clear answers are scarce. However, I assume the importance of engaging with this complex topic. As previously mentioned, the paper wants to propose, on one hand, a new stage in the framework contoured by Greg E. Anderson, which characterised by a changed innovation paradigm and a trend where private Chinese actors are reaching out to acquire foreign companies or invest in them. On the other hand, a new variant of the Developmental State model is put forward, where the state fulfils the role of innovation manager and uses the market as a mean of fixing the imperfections generated by the centralised

economic structure. This new paradigm reveals the central role of the state in the context of the *Knowledge Society*, in contrast with the purely market-driven, liberal, model. Following the review of the literature a gap in the adopted perspectives has been depicted. First, most of the encountered sources are already a few years old, and the NEV environment is highly volatile, being completely different if one compares the year 2020 with the year 2010, in China and globally. Second, most of the authors that are engaging with the NEV sector in China are running the analysis through an inappropriate, orthodox lens which does not take into account the bigger picture. There is a constant tendency in the existent literature that draws comparisons between the Chinese policies' success or failure and the activities of other countries, without having a broader understanding of the state's role. In this sense, this paper proposes a new heterodox approach in the analysis of the Chinese industrial dynamics.

1.4. Disposition

This thesis is structured in six chapters. Following the introductory chapter, the second chapter will present the literature that this study engages with in respect to the Chinese automotive industry and the new energy vehicle sector. The third chapter will showcase the theoretical framework of this research, consisting of the Triple Helix model and the Developmental State model. The fourth chapter will highlight the methodological features of this paper. The fifth chapter will comprehensively introduce the findings of the study, as well as their subsequent analysis. Lastly, the sixth chapter will entail conclusive remarks and reflections in respect to the thesis.

2. Literature review

In this next chapter, I will assess the ideas revolving around the Chinese automotive industry and the NEV sector. In the first subsection, it will be looked at the stages of the Chinese automotive industry, using as main reference point the structure created by Greg Anderson. However, it will be put in relation with the work of other authors in order to have a better grasp of the bigger picture. In the second subsection, I will attempt to do a metaphorical cartography of what has been written until now in respect to the Chinese NEV sector, including the various actors' role in innovation, the reasoning behind the state focus on this sector, and ultimately, why some scholars deem the Chinese NEV development as a failure.

2.1. The phases of the Chinese automotive industry

There is a considerable number of scholars presenting the stages of the Chinese automotive industry development in various forms. Nonetheless, the framework provided in *Designated Drivers* is judged by the present researcher as the most well-structured from the approached works, and thus it will be used as general historical framework for the present paper. Anderson (2012) comes up with a structure made of three stages. Namely, the first stage, named suggestively *state-centric*, starting from 1949 and lasting until 1978, covering the Maoist era; the second stage, called *global partnering*, starting in 1978 and lasting until 2001. Lastly, the third stage, which is labelled as *indigenous innovation*, starting in late 2001 and lasting until present times. It must be mentioned that Anderson's book has been published in 2012, therefore, the *present* of the author was the reality observed by him at that time, more than eight years ago.

The state centric phase has been generally characterised by the post-war period, under the rule of Mao Zedong. The automotive industry became of interest mainly from a utilitarian point of view at that moment in time. The fundamental concerns were related to the automobiles used for agricultural and military activities, as there was no real market demand for personal cars (Chang, 2011). Anderson (2012, pp. 53-55) points out that besides the fact that most Chinese people would not afford a personal car, there was also an ideological clash between such consumerist ideals and the Maoist ideology. This fact resulted into a very low production of personal cars in this period, their great majority being used in the urban taxi fleets, while others were used as official cars. During this period, the first vehicle factory has been built in China. That was First Automobile Works, in 1953, which was built with Soviet counselling, in an area left behind by the Japanese occupation with a satisfactory railway infrastructure

(Harwit, 1995, p. 17). Following FAW, Second Automobile Works is also founded in 1969 – later, in 1992, it becomes the present Dongfeng. It can be observed that even starting with these times, the Chinese automotive industry was strongly dependent on the foreign input, starting with the Soviet help in the establishment of the first assets, as well as in the nascent R&D processes, and ending with the numbers of Western imported cars that were used as taxis and official vehicles simply because the industry was unable to perform well enough, even under these very basic requirements. An interesting aspect is that this is the moment when the seed for future industrial fragmentation was placed. Mao was concerned that in the event of an attack, an industrially developed and concentrated area would be too vulnerable. In this respect, he made sure that the factories will be spread across China, especially in remote areas, away from the sea (Chang, 2011, p. 25). From a theoretical point of view, the state was the kick-starter of a non-existent or highly immature industry. It is important to highlight that even in this early stage of development one can observe the input provided by the foreign actors, as a support for the state-industry relationship.

The global partnering phase starts with Deng Xiaoping's economic reforms, bringing a completely new perspective upon the automotive industry compared to the Maoist era. In Chin's (2010) terms, this is the beginning of the so-called lower phase of domestic automotive industry modernisation. Under the imperative of *learning from the West*, the strategy shifts towards actively assuming the role of the foreign actors in the sense of foreign direct investment and technology transfer (Anderson, 2012, p. 56). Consequently, during the 1980s, the Chinese started approaching American, German, French and Japanese companies in order to partner up locally. This was implying that the Chinese would provide to the foreigners the growing domestic automotive market, while the foreigners will provide to the Chinese top technology. The greatest preoccupation at the time, was to start producing personal cars, given the fact that on one hand, the raising demand could have been observed in the number of imports, and on the other hand, there was a justified belief that without the production of personal cars, modernisation of the automotive industry cannot be achieved (Harwit, 1995, pp. 26-33).

During this period, the Chinese government has no real bargaining power with the foreign companies. Contrary to the elite's expectations, the industrial upgrade strategy barely limps forward, as the three companies that initially accept the JV projects, American Motors Corporation, Peugeot, and Volkswagen, are not engaging in substantial investments, nor do they bring their latest technologies to the table (Chin, 2010, pp. 51-53). The government would have wanted most of the production processes to happen locally, and on top of that, to transform

China into a hub for regional automotive export. However, that was impossible for the foreign actors, because not only the local manufacturers were underdeveloped, but also the local parts suppliers were immature, leaving the Chinese assemblers only with the option of having to import CKDs, until the production quality that was required by the foreign partners could be ensured (Anderson, 2012, pp. 55-60). Besides the negative impact that the CKDs had on the domestic industrial modernisation, there was even a hotter problem for the government at that time. That is, the CKDs were sabotaging the governmental plans of developing a national foreign currency reserve – also a reason staying behind the aforementioned aspiration of becoming an auto regional export hub (Chin, 2010, p. 46).

Since industrial fragmentation was still a great obstacle in the governmental plans, this whole period has been characterised by constant attempts of addressing this Mao-inherited phenomenon. The first programme in this respect was *Big Three, Small Three*, in 1988, which implied that the big three automakers, FAW, SAIC, and SAW, and the smallest three JVs, Beijing Jeep, Guangzhou Peugeot, and Tianjin Automotive Industry Corporation would be the centres of mergers and industrial consolidation. Even though the programme ended up reducing the number of actors in the industry from 124 to 117, it was deemed as a failure given that the goals were not met, in absence of detailed directives from the central government (Chang, 2011, p. 30). Meanwhile, one can imagine that the position of the central government is not the most convenient either. On one hand, it would want to build up an efficient industry in which there are no aimless investments and there would be only a few dominant actors. On the other hand, even the underperforming factories are providing jobs locally, therefore, it would be difficult for the central government to order their closure in this context (Anderson, 2012, p. 69).

In the mid-1990s, the regulators came to the conclusion that the JV strategy does not hold an attractive perspective for the technological upgrade within the automotive industry. Thus, in 1994 the *Automotive Industrial Policy* was revealed. It contained a call for the formation of an *independent* automotive industry. However, this time the message was not propagated in the direction of a Maoist self-sufficiency, but in a way where homegrown brands, indigenous models and technology would be developed (Chin, 2010, p. 105). With this occasion, it is important to highlight Anderson's (2012, p. 66) point in respect to the governmental request of *digesting and absorbing foreign technology*. Namely, the innovation is not portrayed as ground-breaking technology, but as a learning process from the foreign partners that will be later on translated into *independent* Chinese products. This can be precisely

because the officials were both aware of their own modest industrial innovation capacities, and of the incontestable foreign technological superiority. Generally, the ICEV sector was leaving only little room for further ground-breaking innovation. The late 1990s, together with the 9th FYP, bring to the forefront the first glimpses of an early interest towards the NEV sector, being further consolidated in 2001, in the 10th FYP, anticipating the WTO accession (Gong, Wang and Wang, 2013, p. 211).

This period highlights the clear emergence of the industry-state-foreign paradigm. Nonetheless, the state coordinates the entire domestic automotive industry using the traditional tools of the developmental state. One relevant example is that the state regulates what actors are allowed to enter the automotive market, on both domestic and foreign sides – in the former's case, as a way of combating industrial fragmentation, and in the latter's case, as a mean of maximising the profitability of the foreign presence. It could be argued that given the uncontested competitive advantage had by the foreign actors in respect to the local SOEs, the state played the role of protector and negotiator. The governing rhetoric was strongly rooted in the Developmental State model, where no ground-breaking innovation is aimed, and the goals are limited to catching up with the leading industrial pack. Later in this period, the reliance on the foreign actor is discouraged and local R&D is promoted. However, the general mindset regarding innovation is still based on catching up, provided the ICEV context.

The indigenous innovation stage starts in early 2002, once with the Chinese WTO membership, and continues until the writing days of Anderson's book. The JV-oriented strategy was already deemed as inefficient in the mid-90s when the regulators started to have a clearer idea about where the domestic industry should be headed. Now, under the WTO rules, the Chinese were unable to exchange technology for market access at all. Consequently, a new strategy had to be developed. It was based on the development of JV indigenous brands, where the foreign partners had to support the domestic manufacturers with technology in exchange for approvals of production capacity expenditure (Mitchell, 2014). The government was stressing the importance of having independent intellectual property, hoping that this will help the local manufacturers to establish a local dominance in front of the foreign actors (Anderson, 2012, p. 75).

One of the highlights of the late 1990s and early 2000s is the appearance of private actors on the Chinese automotive scene. These are Geely, BYD and, to a certain extent, Chery, which would be more appropriately labelled as *independent*, rather than *private*, given its actual

statute (Dunne, 2011, pp. 125-127). At that time, private actors were technically forbidden from joining the industry, the SOEs were the only ones allowed and capable of producing automobiles. However, there was a small bureaucratic back door spotted by a few entrepreneurs. In order for an SOE to produce a certain a new car model, a set of documents had to be submitted to the government so that the new model is approved and included in the industrial catalogue. There was a general practice that bankrupt factories would sell their licenses to other businesses. This is how companies like Geely, a former refrigerator producer (Reuters, 2010), and BYD, a former rechargeable-battery factory (Gunther, 2009), started their activities in the Chinese automotive industry (Anderson, 2012, p. 80).

Together with the accession to WTO, a lot of planning and concerns were taking over the governmental level. The Chinese actors of the automotive industry were frightened by the fact that this economical opening would lead up to a flood of foreign companies on the domestic market, thus resulting into a complete decimation of any industrial plan that was in place. Nonetheless, this did not happen. On the contrary, the idea of having its existence threatened constrained and disciplined the Chinese automotive industry. The international competition upgraded the industrial environment in China, while the government still had control over it. Ultimately, the WTO membership has stimulated the growth of domestic private actors (Chin, 2010, pp. 214-217). This could be labelled as the turning point when the real value of the market has been realised by both policymakers and businesspeople.

As a result of the 11th FYP, the officials called for the SOEs to be the core of the industry, the private ventures to join the SOEs in their reform, and for the foreign partners to support a win-win strategy in developing technologies with the local manufacturers. This approach shows that the size of the actor was not important anymore. Namely, it was not relevant anymore the production output, but the contribution one could have to the Chinese domination of the domestic market and to technological independence. The government truly acknowledges in this industrial plan the role of the private ventures as facilitators of development through the accentuation of competition, and the policies start to get further from the classic centralised model, thus realising that innovation – and not size – is the key (Anderson, 2012, pp. 82-83). In this period, fragmentation was still a concern for the Chinese officials. It is interesting to observe how the seed planted by the Maoist cautiousness still affects the industry many decades after. A new consolidation plan was issued from the central government, the *Big Four, Small Four*. Similarly to the *Big Three, Small Three*, the *big four* were SAIC, FAW, Dongfeng and Chang'An, while the *small four* were BAIC, GAIC, Chery

and Sinotruk. This has brought to the forefront once again that the government envisions the Chinese automotive industry shaped around the big SOEs. However, it was stated that this initiative was only having a guiding value, in this specific instance (Chang, 2011, pp. 38-39).

Between the last highlights mentioned by Anderson (2012, p. 90) in this period is the 12th FYP, which signals the real start of a comprehensive series of NEV policies by including this sector into the list of seven *new strategic industries*. As Anderson points out here, the NEV sector is viewed as a fresh start in which the foreign companies do not have any advantage compared to the domestic actors. Therefore, it is a race in which the Chinese are competing on level grounds with the rest of the world.

This stage marks the beginning of the end in the industry-state-foreign core value. Namely, foreign actors are not completely dismissed, but they lose their importance in comparison with the previous period. Nevertheless, the Chinese innovation network experiences the appearance of private actors which start gaining a role in tackling industrial fragmentation and encouraging technological advancement through competition. The state starts to slowly emerge as a moderator of the growing network, while innovation starts to become gradually important. The clear transition to the new developmental state variant only manifests once the ICEV focus is left behind and the NEV reaches industrial focus. That is specifically because the ICEV technologies did not stimulate the importance of ground-breaking innovation for the Chinese industry.

2.2. New energy vehicles development

In the following subsection, it will be presented the overall view of the English-speaking academia in respect to the NEV sector in China. Some articles might have been missed in the literature search process. However, the number of articles on this topic that the present researcher has entered in contact with is satisfactory and they are believed to be representative for the general academic perspective. Also, it is important to mention that six out of the seven found articles date from 2015 or earlier, given that the year of writing is 2020, and the first Chinese NEV pilot programme started in 2009. These seven articles have been processed through a qualitative analysis software in order to depict the major themes approached in them. The coding process resulted into the following three subsections: the roles of the state, the private actors and the foreign actors, why does the government focus on the NEV sector, and lastly, why is the Chinese NEV development judged as unsuccessful under certain circumstances. The *state* in the context of this paper represents central and local governments,

SOEs, and academic entities. Even though each of these four types of actors might have an own agenda, the present researcher has deemed important to highlight the contrasts between the *state faction*, the *private actors' faction*, and the *foreign actors' faction* by essentialising the actors into more general categories.

2.2.1. The roles

The NEV strategy overall revolves around the idea that technological innovation can come from the government and from grand planning (Howell, Lee and Heal, 2014, p. 7). That is why, the literature engaged with the study of the NEV phenomenon majorly focuses on the State. Namely, its industrial central planning, the programmes that it developed, and ultimately, its role in innovation networks. The NEV strategy started in the eighth period of the five-year planning, in the first part of the 1990s, and since then significant resources have been dedicated in it by the government (Kimble and Wang, 2013, p. 15). Nevertheless, its results started to unveil only at the beginning of the 2000s, together with the PRC's WTO membership. Liu and Kokko (2013, pp. 22-23) split the Chinese state led NEV development in three stages: the research (2001-2009), the public sector use (2009-2010), and the consumer subsidies (starting with 2010). Their assumption is that, initially, the market was not at all a driver for the NEV development, but that specifically the governmental intervention was. In their text, this assumption is backed by the fact that in general, the market dynamics are not enough for the drive of the new energy sector. However, their lens uses precisely a traditional interventionist perspective, without reaching the full picture of the state's role.

The highlight of the research stage is the 863 Program of the Ministry of Science and Technology. The governmental program has set the NEV development as a priority and directed around 2 billion yuan towards the R&D conducted by car manufacturers, universities, and research institutes. Furthermore, the funding was based on a three *horizontal* and three *vertical* schemes, where the *horizontals* were vehicle control systems, motor drive systems, and power battery/fuel cell technologies, and the *verticals* were hybrid electric vehicles, pure electric vehicles, and fuel cell vehicles (Gong, Wang and Wang, 2013, pp. 210-211). Once the Chinese automotive industry managed to come up with a few NEV prototypes, the policy packages moved towards creating a market for the NEVs, focusing specifically on hybrids and pure electrics, and leaving aside the fuel-cell vehicles. In 2009, as a method to reduce the impact of the 2008 crisis, the government publishes the *Automotive Industry Readjustment and Revitalization Plan*, including targets for the production capacity, 10 billion yuan aimed at

developing motors, battery technology, management systems, and design, and other measures that would raise up the NEV demand such as charging infrastructure (Liu and Kokko, 2013, pp. 22-23).

Simultaneously, the government also starts its first pilot programme involving NEVs, known as *Thousands of Vehicles, Tens of Cities* (TVTC). The program wanted to demonstrate BEVs, HEVs and FCEV in public service vehicle fleets, including buses, taxis, and government vehicles, initially in 13 Tier I cities, and subsequently, in 7 Tier II cities and 5 Tier III cities (Gong, Wang and Wang, 2013, p. 212). The consumer subsidies stage emerges in 2010, once the government together with the National Development and Reform Commission issued the *Notice on Subsidies for Private Purchases of New Energy Vehicles*. It entailed subsidies for private purchases of BEVs and PHEVs in five pilot cities, Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei, which, interestingly enough are the locations of five important manufacturers' headquarters – that is, SAIC, FAW, BYD, Geely, and Chery. The subsidised amount would be dependent on the type of the vehicle, BEV purchases benefiting of larger subsidies compared to PHEV. Some local governments would put forward additional subsidies, besides the ones received from the central government, such as in the case of Shanghai (Liu and Kokko, 2013, p. 23).

The role of the private sector is very marginally presented in the approached existing literature. Lauer and Liefner (2019, p. 450) provide the example of Shenzhen, where the private company BYD helps the local government in drafting comprehensive policies. However, in general, private companies require different instruments compared to the governmental actors, i.e. instruments that would differ from subsidies, binding quotas, and direct orders. Interestingly enough, none of the approached literature pieces explicitly mention the role of the private actors as drivers of the competition on the market, given that the ICEV-related literature constantly reiterates this role. Ultimately, the role of the foreign actors is barely distinguishable according to the NEV-related literature. The only instance in which they appear are as a mention of the GM, Toyota, and Honda joint ventures that were producing their own hybrid vehicles locally, for the Chinese market (Liu and Kokko, 2013, p. 21).

2.2.2. Why does the government focus on the NEV sector?

The approach works have identified three main reasons behind the extend governmental interest expressed towards the NEV development. These are energy security, industrial advantage, and pollution. An important aspect that must be mentioned is that these three

arguments are interlinked, and the NEV sector has been conveniently found at their intersection. Thus, none of them should be treated as less important in comparison to the others (Howell, Lee and Heal, 2014, p. 3). The energy security concern is related to China's high reliance on imported oil. Namely, oil imports are continuously increasing, while the domestic oil production is stagnating, leading to the year 2010, when more than 54% of the crude oil supply was imported (Gong, Wang and Wang, 2013, p. 203). Its dependence on foreign countries has also extended to coal and natural gas (Howell, Lee and Heal, 2014, p. 3). The reliance on foreign actors goes against the ideal of self-sufficiency (Liu and Kokko, 2013, p. 21).

On the other hand, when it comes to the industrial advantage argument, the government believes that sustainable economic growth depends on upgrading the industry to a higher value role in the global supply chain. The NEV sector is a perfect fit for such targets. It is envisioned that the creation of a large domestic NEV market would offer a launch pad for a Chinese global expansion (Howell, Lee and Heal, 2014, p. 4). This new sector is invested with the hope that it will close the existent industrial gap between China and the other developed economies, given that competitors did not establish a strong advantage yet (Liu and Kokko, 2013, p. 21). Lastly, the pollution dimension has been a recurrent concern of the industrial planning because it is a visible issue that tests the governmental ability to respond to public expectations (Howell, Lee and Heal, 2014, p. 3). The *Notice on work of continuous promotion and application of new energy vehicles*, published by the government in 2013, stipulates the conditions of NEV subsidies in megacities like Beijing, Shanghai, and Guangzhou. Not surprisingly, these are the most affected places by air pollution phenomena such as fog and haze (Yuan, Liu and Zuo, 2015, p. 305). An additional concern related to pollution is that most energy plants are coal powered in China, revealing the fact that most probably the NEV mass-usage would not have such a great impact on the environment. However, NEVs would transport tailpipe emissions from the urban areas to the remote areas where electricity is generated (Gong, Wang and Wang, 2013, p. 208).

2.2.3. Why is the focus judged as unsuccessful under certain circumstances?

The last major theme found in the existing literature was related to identifying the reasons behind the alleged failure of the NEV-targeted governmental policies. The main reasons are lack of charging infrastructure, regional protectionism, immature technology, and in one isolated case that was found to bring up an interesting perspective, lack of awareness towards

customers' preferences. Yuan, Liu and Zuo (2015, p. 304) point out the NEV dependency on downstream supporting infrastructure, while mentioning that China falls behind countries like Germany, the United States and Japan in this respect because the charging facilities are limited to the pilot cities. Nonetheless, this article was written in 2015, and more recent reports regarding the current charging infrastructure should be considered (see Bloomberg, 2020). Secondly, Howell, Lee and Heal (2014, p. 10) highlight that Chinese cities are creating trade barriers, purchasing only from local manufacturers. For instance, governments in Guangzhou would buy only from BYD, while in Beijing taxis are bought from the Beijing-Hyundai JV and in Shanghai only from the SAIC-VW JV. Technological immaturity is a frequently invoked reason for NEV failure. Yuan, Liu and Zuo (2015, pp. 303-304) emphasise that the current mature battery technologies, such as the Metal hydride nickel dynamic battery and the Lead-acid battery, have massive limitations in respect to life cycle and power output. Likewise, the power train control system, motor and its control system require further research and development. Lastly, Zhang et al. (2013, p. 390) came up with the assumption that both governmental NEV policies and the NEV market itself might fail due to the lack of knowledge in respect to the new technology and consumer preferences.

As concluding remarks on this subsection, on must take into account that China is not the only state focusing and struggling with the NEV sector. The core problems related to this new sector are the same in the rest of the world, namely high battery costs, long charging times, and no comprehensive business model for charging infrastructure (Howell, Lee and Heal, 2014, p. 3).

3. Theoretical framework

This chapter will provide a presentation of the central theories that this paper is engaging with, namely, the Triple Helix model, and the Developmental State model. These theories will be used as point of reference in the analysis of the findings.

3.1. A variation of the Triple Helix model

The Triple Helix innovation model proposes the emergence of a triadic relationship between university–industry–government, within the *Knowledge Society,* as opposed to the traditional dyadic relationship between industry–government in the *Industrial Society* (Trott, 2016). The present theoretical framework has been chosen to contextualise the findings of the social network analysis that was conducted in this paper. Even though the model was originally designed around the introduction of the academical faction in the industry-government paradigm, the framework itself is highly flexible when it comes to the roles of the three spheres. As long as the third type of actor is declared as source of variation, the focus of the analysis can be concentrated on the other two types (Leydesdorff, 2013, p. 1847).

Etzkowitz (2008) proposes two configurations of the Triple Helix. That is, a statist model, where the government controls the academia and industry, and a laissez-faire model where industry, academia, and government are operating separately, and the interaction between them only happens modestly and under specific circumstances. The statist model seems to describe, to a certain extent, the dynamics of the Chinese innovation network, based on the findings of this paper. Etzkowitz further describes the statist configuration as a paradigm in which the industry and the university are subordinate parts of the state, and due to their weak positions that are in need of directives, the government is expected to take the lead in managing plans and resources for any new initiative. Assuming that the ideal goal of the Triple Helix model is the development of strong interdependencies between the three spheres, the statist paradigm can experience a movement towards decentralisation as the country gets closer to the knowledge-based economy. However, the state will still be the one holding the most power in the innovation policy making (Pan, 2016, p. 115).

The important theoretical difference that is made in this paper is that the statist variant manifests differently in China. Namely, the state fully manages and dominates the innovation network involving SOEs and universities. Nevertheless, it does not have the same role when it comes to innovation networks that involve private actors. Practically, we can observe the existence of two different network dynamics that manifest together, under the direct

management of the state. As it is portrayed in *Fig. 1*, on one hand, we observe a side of the network that involves the state (i.e. central or local government), the SOEs as a representation of the industry, and the national universities, and on the other hand, a network that involves the state, the private actors, and the foreign actors. Given that all types of actors, regardless of their sphere, have a vital defined role in the national and regional innovation systems, the concept of hierarchy becomes obsolete and is replaced by an interconnected network. That is not to say that the state is powerless in front of this new system. Contrary to that, it is a system designed specifically by the state in which the state is playing the managerial, central role. Moreover, interactions exist between actors that are not directly connected. However, these interactions are, one way or another, mediated by the state, hence the absence of direct links.

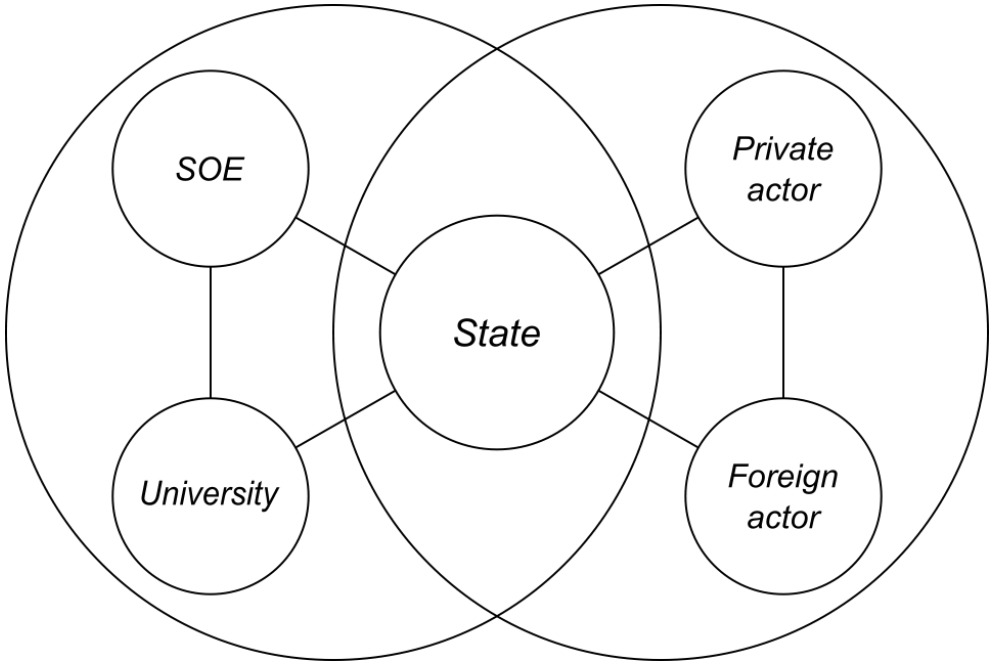


Fig. 1 – The innovation network of the New Developmental State represented as two interconnected Triple Helices. (Source: Author)

The interaction proposed by the Triple Helix model, university–industry–government, is at its core the conceptualisation of the interaction between science-economy-policy (Leydesdorff, 2013, p. 1849). This dichotomy of functions is clearly visible when one looks at the faction containing university-SOE-state, however, in the second instance, foreign-private-state, the separation between science-economy is not as clear. That is because the private sphere practices an inhouse innovation process. Furthermore, under certain circumstances, the private actors would also reach out to foreign technology to either purchase

or invest in it, compensating the general lack of access to universities. Essentially, this behaviour is showing more a strategy of adaptation rather than a manifestation of the ideal Triple Helix (Etzkowitz et al., 2007, p. 15), where the three spheres would start to *share* roles with each other, given their strong interconnectivity. Nevertheless, the foreign actor is assimilated at its core with the scientific role in this specific context.

3.2. Developmental State model

To further contextualise and explain the role of the Chinese government in the framework of the *Knowledge Society* and economic growth achieved through innovation, the Developmental State model will be used as second point of reference. Although there is no unanimously accepted definition of the concept (Knight, 2014), this paper will adopt the definition of the developmental state, in its traditional form, as:

> "(…) states whose politics have concentrated sufficient power, autonomy and capacity at the centre to shape, pursue and encourage the achievement of explicit developmental objectives, whether by establishing and promoting the conditions and directions of economic growth, or by organising it directly, or a varying combination of both." (Leftwich, 1995, p. 401)

This model has been constantly used to describe forms of state capitalism in Asia, ranging from Chalmers Johnson's *Japanese economic miracle* to David Kang's *South Korean crony capitalism*. Nonetheless, all the forms of state capitalism entailed by this model revolve around a heterodox economical system that challenges the mainstream, market-oriented logic (Haggard, 2018, p. 2), and in which the government plays a central role through its ability of drafting industrial policies. The core idea of this paradigm is that developing countries require the state to assume a developmental role in the direction of driving industrialisation, and, implicitly, economic growth (Johnson, 1982, pp. 19-20). Practically, the Developmental State model has been the Western way of explaining how the East Asian economies did manage to catch-up with the industrialised states. In this respect the main source of legitimacy for a government that adopted this strategy is precisely economic growth. Leftwich (1995) identifies six major components of the traditional developmental state: a determined developmental elite, a degree of autonomy, a powerful economic bureaucracy, a weak civil society, an efficient management of the private economic interests and regime legitimacy. Under this framework,

the state-industry dyad is essential, and the main dynamic consists in an industry highly relying on the state's support. In this sense, the state's developmental tools revolve around regulations, financial incentives and development banks (Trubek et al., 2013, p. 114).

A related explanation of the Developmental State model is the Flying Geese Paradigm (FGP). The FGP is a theory explaining how undeveloped countries can advance their position in the international industrial scheme (Korhonen, 2016). Specifically, it describes how emerging economies transit from light and heavy industries, to the knowledge industry, characterised by technology- and capital-intensive activities and achieved by emulating the leaders of the industrial chain (Haggard, 2018, pp. 15-16). A vital aspect is that, under these circumstances, the traditional developmental state cannot be the leader of the international industrial chain. Namely, it cannot operate at the technological frontier. That is because, according to the Flying Geese Paradigm, this strategy can be fruitful only as long as it has a clear path to follow. This belief resides in the idea that the state cannot innovate, thus the market has to be left to secure its role in the knowledge industry, and the state has to step back (Abrami, Kirby and McFarlan, 2014).

Pan (2016) produced a variation of this developmental pattern, correlating it with the Triple Helix model. Pan's variation distinguishes between four stages that a country navigates through, based on its position in the global value chains. Those are low-tech industrialisation, industrial transitional phase, high-tech industrialisation, and innovation take-off. Each stage is characterised by a different set of interactions between the three spheres of the Triple Helix. That is, the low stages of development present a weak triadic configuration between government-industry-university, while the last stage displays a fully consolidated configuration where the three spheres are tightly interconnected. The correlation between the Triple Helix model and the Developmental State model that Pan proposes wants to highlight the fact that none of the three spheres can attain the ideal *innovation take-off* by itself and that a robust trilateral relation is required.

In order to explain the phenomena observed in the Chinese case, in addition to the variant of the Triple Helix paradigm put forward in the previous subsection of this chapter, the present thesis also suggests a new version of the Developmental State model. The limitations of the state in the traditional renditions of the theory are compensated through the development of innovation networks. Namely, the state is not simply an investor and a regulator of the industry, but it also plays the role of innovation manager, facilitating the interconnectivity

between the various kinds of actors, on one hand, and creating a favourable context for innovation through initiatives and regulations, on the other hand. More importantly, this new manager role also comes with a new tool, the market, as a vital addition to the traditional tools of the developmental state. The orthodox economic system features an environment where the market operates freely and, only under limited circumstances, the state would intervene to correct market imperfections. In contrast, the new variant of heterodox theory proposed by this paper showcases the centralised economic model as the status quo, while free market characteristics are carefully introduced in order to adjust the inefficiencies generated by the state-led economic arrangement. The centralised economic model in this context is not the expression of a transitional period. On the contrary, the state has an indefinite role in the national economic development, trading the legitimacy gained through constant economic growth, for the legitimacy gained through constant innovation. This means that the newly proposed Developmental State is not portraying a dynamic model. Conversely, it theorises a static model, where the market becomes a new tool that the state can use in order to sustainably operate at the technological frontier.

4. Methodology

This chapter will address the methodological dimension of the present thesis. The first subchapter briefly presents the adopted stance and research design. The second subchapter discusses the data collection process by presenting exhaustively what types of data have been be analysed, how data has been handled and collected, and why certain types of data have been chosen over others. The third subchapter entails personal reflections that are relevant to contextualise the research itself as well as the path that was taken in order to achieve the present conclusions. The fourth subchapter highlights the assessed challenges and limitations that have been observed and experimented throughout the study. Lastly, the fifth subchapter will talk about self-reflexivity and ethical issues.

4.1. Research design

The research design of this academic piece could be framed as a form of inductive study, rooted into a grounded theory normative, that uses triangulation. In this context, grounded theory is not necessarily describing a method, but the general context of the research. Even though Strauss and Corbin (2014) are distinguishing between three different types of grounded theory based on how the coding process is approached – i.e. open coding, axial coding, and selective coding – Charmaz (2006, p. 9) proposes a definition of the grounded theory as "a set of principles and practices, not as prescriptions or packages". That is precisely what grounded theory consists in, given the context of this paper, a set of principles. The guiding principle of this research design stands within the close relationship that exists between data collection, analysis, and theory. That is, the way in which theory derives from the data collection process in order to describe the *reality* (Strauss and Corbin, 2014, pp. 12-13).

On the other hand, according to Bryman (2012, p. 392), triangulation consists in "using more than one method or source of data in the study of social phenomena". This research will use a between-method triangulation type, which "combines dissimilar methods to measure the same unit" (Denzin, 1978, p. 302). The most important aspect of this chosen research design is that the different findings will not be necessarily used to confirm each other, but to enrich the overall perspective upon the study (Carvalho and White, 1997). Indeed, the association between grounded theory and quantitative research is unusual. Nonetheless, the current research design lends the general principles from the grounded theory approach in order to create the appropriate context for a study representative for the Chinese realities.

4.2. Data collection

The types of data used for this thesis paper are mainly of three types. Namely, there have been used international and Chinese patents obtained from the European Patent Office's free online resource, Espacenet, official documents issued by the Chinese government obtained via Peking University's website pkulaw.cn, and news pieces from Chinese and international media outlets accessed either through their websites or through the research tool Nexis Uni. At the beginning of the research process, there has been an attempt of getting in contact with multiple representatives of European and Chinese associations, institutions and businesses in order to get insightful information regarding the dynamics of interest, but no answer was received. Given the various types of data that have been used, the triangulation method was deemed to be appropriate.

4.2.1. Mining and normalising the patents

Due to reasons related to reliability and replicability, it is important to specify how one has got to the analysed patents and how the raw results have been manipulated. First, the patent mining sessions have been conducted on the European Patent Office's free tool, Espacenet, by searching for specific keywords related to the subject of interest and filtering the results for patents that have been published in the period 2008-2018. The period has been deliberately chosen based on a few arguments. After conducting a few tests, it has been assessed that the interest for the NEV sector in China, from an intellectual property perspective, have started ramping up around 2008. On the other hand, it has been decided to take a buffer zone between the time of writing and the analysed period and thus the year 2018 has been chosen. The keywords have been chosen based on which technologies have been advertised by the Chinese government as R&D priorities, for the first patent mining sessions. Subsequently, other mining sessions have been conducted with keywords designating popular NEV-related technologies, such as *vehicle-to-grid* (V2G), *solid-state battery*, and *Internet of Things* (IoT).

Second, names of certain patent applicants have been changed so that there are no name variations of the same company. On the account of transcribing Chinese names in English, in many cases applicant names contained inaccuracies, resulting into multiple names attributed to the same company. Third, certain patent applicant names have been changed with their parent company's name due to the related goal of the current research – determining centrality and influence in innovation networks. For instance, under this step, "Zhejiang Geely New Energy Commercial Vehicles Co Ltd" would become "Geely Holding Group Co Ltd". However, in

the case of joint ventures it is not applicable. For example, "SAIC Volkswagen Automobile Co Ltd" would not be assimilated into "SAIC Motor Corp Ltd". Other illustrations of major exceptions in this stage have been NARI Technology Group and XJ Group, which were not assimilated to State Grid Corporation, even though they are subsidiaries. Fourth, certain patents have been removed completely due to the irrelevant expertise area of their applicants, such as aeronautics, trains, large commercial vehicles. Fifth, certain patents have been removed completely from the list if the inventor has waived their right to be cited. Lastly, patents where the inventors did not apply through a company have been also removed from the list. It has to be mentioned that the number of deleted patents compared to the raw number of patents is marginal and will not affect the outcome of the present thesis in any way. The total number of analysed patents amounts to approximatively thirty thousand.

4.2.2. Data analysis

The data analysis process has been be split based on the type of analysed data into quantitative and qualitative. Namely, the patents have been gathered and examined through a quantitative network analysis lens using the Gephi social network analysis and visualization software, while the official documents and news pieces have been subjected to ethnographic content analysis (ECA) using the NVivo qualitative data analysis software. First of all, as presented by Otte and Rousseau (2016, p. 441), social network analysis (SNA) is "a broad strategy for investigating social structures" through networks and graph theory. The design of the present SNA is egocentric, as opposed to whole network, having Chinese state actors such as State Grid Corporation focused throughout the study. This type of design concentrates "on a focal actor or object and the relationships in its locality" (Carrington, Scott and Wasserman, 2005, p. 8).

Secondly, Bryman (2012, p. 557) defines qualitative content analysis as an approach which is "searching out of underlying themes in the materials being analysed". This study has used a method resembling the one proposed by David L. Altheide, specifically, ethnographic content analysis. According to him, ECA "follows a recursive and reflexive movement between concept development-sampling-data, collection-data, coding-data, and analysis-interpretation", while remaining systematic and analytic, but not rigid (Altheide, 2011, p. 16). Practically, Altheide suggests a model where premade categories guide the initial coding process, though it is expected to have new emerging categories once the coding process advances. ECA has been chosen for approaching the qualitative side of this research as it was judged most appropriate in respect to the grounded theory's ideals. Altheide's model have been

exactly the guiding mechanism in the coding process of the official documents and the media articles. Namely, a set of general codes have been initially set up in NVivo, followed by constant adjustments and modifications related to either adding new codes or renaming the already existing ones, depending on the patterns observed in the consulted data.

The aforementioned methods and types of data have been selected in accordance with the research questions. Precisely, the enrichment feature of the triangulation approach is of great importance in answering the queries of this thesis. That is because the NEV phenomenon manifests on multiple layers, requiring first and foremost a comprehensive understanding of the sector's stakeholders. The used data represents all the involved dimensions. Namely, the official documents unveil the state's role and agenda, while the news pieces showcase how the state agenda manifests in the citizens' lives and in the business sector, finally rounding up with the patents, which are the desirable and *palpable* end product of both governmental and corporate levels.

4.3. Reflexivity

The initial plan of this thesis consisted in a completely different set of assumptions. The initial hypothesis of this paper was related to the importance of the Chinese joint ventures in the recent history of the automotive industry. Practically, there was an inherent belief from my part that joint ventures are the true driver of the Chinese automotive industry. This completely changed once I have started conducting the patent mining process. That is the moment when I have realised that the initial preoccupations of my study were irrelevant and unfounded, and decided to let the data speak for itself. It has been surprising to observe how the three types of data that I have used naturally complete each other in a coherent narrative. Even though the inductive approach took over this research project by accident, it would be naïve to imagine that it has achieved the ideal academic objectivity. Bulmer (1979 cited in Bryman, 2012, p. 574) rightly points out that the researcher might be unable to hold back their pre-existent awareness regarding the relevant concepts or theories related to the researched topic. That is precisely why the introduction of this chapter stressed Charmaz's idea of grounded theory as *set of principles and practices*. Absolute objectivity and neutrality should constantly be categorical imperatives for researchers. Nonetheless, these ideals can never be fully achieved.

4.4. Challenges and limitations

Having in mind that this research does not include actual fieldwork, the challenges of this study might be much more limited. Practically, the data collection process did not depend on the

subjects' input, like in the case of interviews or focus groups. Another notable dimension is the limitations regarding the chosen topic. Intellectual property is a generally sensitive topic for both Western and Chinese actors, especially when it comes to emerging sectors, where innovation makes the difference between success and failure. Consequently, this might have limited the amount of information one has got on this subject.

The most important limitation of this paper is language. Namely, I do not have any knowledge of Chinese. This aspect can become problematic when looking at official documents that have full-text version exclusively in Chinese. Fortunately, pkulaw.cn offers access to English translations of various official documents belonging to the Chinese government. Out of the seven official documents that have been consulted for the present research, six had English translations available, and only one was exclusively found in Chinese. In this sense, there a series of steps have been taken towards coding and understanding the document. Namely, in first instance, Google Translate has been used to translate the whole document. Subsequently, for the sections that had unclear translations, a colleague from Lund University has been approached for further explanations. Under certain circumstances, having a third-party entity involved in the coding process can be problematic due to certain nuances that can escape the understanding of the main researcher. Nonetheless, translation was required only by one official document out of the total of seven and it is believed that no nuances have been *lost in translation* during the process, due to the nature of the documents in question. Furthermore, given the lack of language knowledge, some rather important news pieces might have escaped the coding process, simply because they did not have an English version. However, there have been conducted aleatory tests with media articles of Chinese language to check whether the patterns found in the English sources differ. No real discrepancies have been found.

A secondary limitation of this thesis is the difficulty posed by distinguishing between important and less important patents. Usually, in order to determine the real impact of a given patent, studies must be conducted to determine the invention's translation onto the market. Nevertheless, the present thesis does not aim to assess the innovation related success of specific actors, nor does it want to evaluate their market impact or weight. In contrast, the thesis aims to present the innovation networks' environment overall and review the centrality of certain actors' connections in respect to their attributed patents and the other actors. Furthermore, the current study does not aim at producing grand theory in the way Bryman (2012, pp. 21-22)

defines it. The findings of this study want to describe solely the Chinese context of the automotive industry.

4.5. Ethical issues

Bryman (2012, pp. 304-305) is characterising qualitative content analysis as transparent, unobtrusive, non-reactive, flexible, and, to a certain extent, suitable for students inferior to the doctoral level. The same features could be easily transferred to the type of network analysis that has been conducted for the present thesis. The ethical dimension is not a determinant aspect of the current study. It is not to be said that this aspect has been neglected throughout the process, although the ethical considerations implied by this type of research are limited. That is because there has been no direct interaction between the researcher and the studied subjects. Furthermore, the actors that are indirectly involved in this study are comprised of states, companies, and renowned associations. The power relation between the observant and the observed in this context is greatly tilted in the favour of the latter.

5. Findings and analysis

In the following chapter I will present the findings and analysis of the present research project. The first subsection will run through the approached official documents and state policies, thus tracing down the industrial framework created by the state. The second subsection will present the identified focused technologies as well as the characteristics of their subsequent innovation networks. The third subsection will present the patterns that have been depicted within the analysed networks, together with the actors that stand out within these patterns. In the last subsection, two brief case studies on the importance of State Grid China Corporation and the Chinese Academy of Sciences within the innovation networks will be conducted.

5.1. State documents

In order to assess the framework created by the Chinese government in the NEV sector, the present study has engaged with seven different official documents issued by institutions such as the State Council, the Ministry of Industry & Information Technology, and the National Development and Reform Commission (NDRC). From these seven documents, three of them have been determined as remarkably important in respect to their regulatory weigh, namely *Notice of the State Council on Issuing the Planning for the Development of the Energy-Saving and New Energy Automobile Industry (2012-2020)*, *Guiding Opinions of the General Office of the State Council on Accelerating Promotion and Application of New-Energy Automobiles* and *Provisions on the Administration of Investments in the Automotive Industry*. Following the coding conducted in NVivo, two major topics have clearly emerged. These are, on one hand, what kind of measures are taken and encouraged by the state in order to pursue advancements in the NEV sector, and on the other hand, what is the form taken by the NEV development. These documents clearly portray the old tools used by the Developmental State, namely regulations and financial incentives. However, the new, revolutionary tool is also mentioned in the normative narrative, namely the market. This feature provides the puzzle piece that will later on contribute to the full picture of the new Developmental State model.

5.1.1. Initiatives and measures

A key recurring message enshrined in at least five documents out of the seven analysed is related to the interaction between the state and the market. Namely, it is stressed that local governments should not distort market dynamics by granting financial or land incentives to local enterprises (State Development & Reform Commission, 2018, Art. 38), companies should not be forced to procure batteries, electric motors or other products from local manufacturers,

and most importantly, NEV manufacturers should not be restrained from entering regions other than their home region (The State Council of the People's Republic of China, 2014). In this sense, the *outstanding business leaders* should be supported through essential factors of innovation (Ministry of Finance et al., 2019). A few leading enterprises are encouraged to emerge in key technologies (e.g. electric motors and electric transmission systems), and, as a result, to develop a strong international competitiveness (The State Council of the People's Republic of China, 2012). A very interesting and rather peculiar article has been found in one of the documents:

> "Art. 3 Enabling the market to play a decisive role in the allocation of resources in the automotive industry and making better use of the role of the government shall be adhered to; the principles of simplification of administrative procedures, decentralization of powers, combination of decentralization and regulation, and optimization of services shall be adhered to; opening, cooperation and fair competition shall be adhered to; and he who invests is responsible, he who grants approval conducts regulation, and who is in charge conducts regulation shall be adhered to." (State Development & Reform Commission, 2018)

The same document is also talking about how investment projects related to the NEV sector should be carefully managed so that underperforming enterprises are avoided. In this regard it is recommended to invest in regions "of good industry foundation, complete innovative factors, strong supporting capacity and large development space and key areas for air pollution prevention and control" (State Development & Reform Commission, 2018, Art. 8). First of all, it is noteworthy to observe how the Chinese central government is preoccupied by the failures of the past ICEV development experiences. Namely, it tries to avoid the industrial fragmentation and the subsequent regional protectionism and favouritism. The central government attempts to get the local governments on the same page, so that a unitary mindset is implemented at the policy making level.

The preoccupation for the *outstanding business leaders* is a constant feature of the Chinese industrial planning since the beginning of the automotive industry. However, in the past the state was fulfilling the role of a highly protective mother for all the national champions. This can be once again explained through the fact that the Chinese government clearly identified the

outstanding advantage that foreign automotive actors had compared to the domestic ones. Given the new industrial configuration provided by the NEV sector, the government becomes a manager for the domestic enterprises, while the crucial role is played by the market. The market will be able to filter, upgrade or punish, depending on the innovation capabilities that a given enterprise possesses or not. That is precisely why the central government puts such a great emphasis on getting the local administrations to become objective regulators. The local policymakers should establish a favourable framework for the emergence, and then sustainability, of internationally competitive enterprises, while the investors should take full responsibility for the performance of their projects. Where the market is unable to coherently correct certain behaviours, the state will step in, using a credit system that indexes enterprises' violations of the imposed standards (Ministry of Industry & Information Technology, 2017, Art. 24).

In the governmental acceptance, such favourable framework also involves the traditional tools of the developmental state, namely subsidies and other types of financial incentives. These means would kick-start a new industry in the absence of an appropriately configured market. On one hand, subsidies and tax exemptions should be granted to private purchases of pure electric vehicles, plug-in hybrid electric vehicles or fuel cell vehicles (The State Council of the People's Republic of China, 2014), and on the other hand, funding for R&D should be provided to enterprises.

> "The central public finance shall arrange funds for extending appropriate support for executing technology innovation projects of energy-saving and new energy automobiles, for directing enterprises to increase investment in such processes as technological development, engineering, formulation of standards, and market application, and for establishing a system of technological innovation with combination between industries, academia, research institutes and users." (The State Council of the People's Republic of China, 2012)

Furthermore, the NEV targeted subsidies should promote the *survival of the fittest* in the industry, thus minimising the side effects such aid has upon the market dynamics (Ministry of Finance et al., 2019). The essential takeaway is that subsidies are not meant to make enterprises fully dependent on the state intervention, they are merely a temporary measure

adopted in order to compensate for the high costs that the development of new technologies poses for both enterprises and users. By contrast, the governmental end-goal resides within the automotive industry's self-reliance; precisely within its evolution towards a sector purely driven by market demand and innovation capacity. The state envisions its role as the centre of the technological innovation system, bringing together policy, economy and science under the form of collaboration between industries, academia, users and policymakers.

In early documents, it can be observed that the government wants to be an example in the usage of NEVs. The central government was calling in 2014 for the local governments and competent departments to foster the usage of NEV in the public sectors of transportation, sanitation, and logistics. Furthermore, the official vehicles of the Communist Party and other public institutions should be predominantly NEVs, therefore, playing a *demonstrative* and *guiding role for the society* (The State Council of the People's Republic of China, 2014). Practically, given the lack of initial demand for NEVs and the associated immature technologies, the government embraces the role of the user. In this sense, demand is stimulated artificially in the beginning of the development, until the real market demand establishes. Another mean of stimulating market demand is the press. Television, radio, newspapers and internet-based outlets should highlight the positive impacts had by NEVs against pollution and energy consumption (The State Council of the People's Republic of China, 2014). Besides its role in encouraging private purchases of NEVs, the media should also endorse the importance of charging infrastructure in order to attract social capital investments in this area (**国家**发展改革委 and **国家能源局**, 2015). It is interesting to point out that the state is trying to encourage private investments in charging infrastructure. Therefore, there is not necessarily an inherent will of monopoly over the charging infrastructure, but the context pushes the Chinese government into taking action towards developing such infrastructure through its own means.

5.1.2. Forms taken by the NEV development

The principal aims of the policymakers in respect to the NEV sector are related to charging infrastructure, battery recycling and vehicle core technology. The above three cannot be developed independently, they are all interrelated and have at their centre the battery. Nonetheless, depending on the general stage of the NEV development, one of them can be slightly prioritised over the other two. The state's focus on charging infrastructure can be explained, from the Chinese perspective, with the *pile station first* principle (**国家**发展改革委

and 国家能源局, 2015). This means precisely that charging infrastructure is massively prioritised. To a certain extent, it could be interpreted that the governmental perspective aims at having charging stations before there are any NEVs needing them. Such aspect is precisely justified by the one of the obvious challenges faced by the green vehicles globally – i.e. range anxiety. One of the major factors determining the sales of NEVs globally is related to battery capacity and charging infrastructure characteristics (namely, the number of available charging piles and their charging time) (Coffin and Horowitz, 2018). The governmental documents are marked by a constant call for further development of charging infrastructure. The construction of electric recharging facilities, as well as the transformation of the supporting electric power grids have to be included in general urban planning and future construction projects (The State Council of the People's Republic of China, 2014). The number of charging piles should satisfy demand both in key regions and between cities (The State Council of the People's Republic of China, 2012). It is of utmost importance that the charging stations are respecting the imposed industrial standards, and that significant compatibility levels are achieved between various manufacturers of charging equipment and NEV brands (国家发展改革委 and 国家能源局, 2015).

The government is frequently compiling in its documents lists of innovation targets. Most of them are consisting in the formulation of technical standards for charging facilities, developing technologies for the connection to a power grid (such as monitoring and billing the usage of the charging facilities), and applying technologies that would facilitate a greater integration and reciprocal interaction between the grid and the vehicle (such as V2G) (The State Council of the People's Republic of China, 2012). Lastly, it is important to mention that the government acknowledges the fact that subsidies are only temporarily granted and that once the subsidies for NEV purchases are phased out, the budget of the local governments should be instead redirected towards building charging infrastructure and other supporting operation services (Ministry of Finance et al., 2019). The Chinese governmental perspective is a mature one, realising the utter importance of the charging infrastructure for the overall NEV development. In the absence of private investment in this area, the state is taking direct action. The market dynamics are deemed as insufficient for the effective initial progress of the charging infrastructure, given the unattractive characteristics of such risky investment from a private actor perspective.

Simultaneously, advancements in vehicle core technologies are also essential. It is stated that the NEV industry should be *scientifically* planned, by focusing on new light-weight materials, efficient drivetrains and traction batteries, IoT technologies and battery management systems (State Development & Reform Commission, 2018, Art. 9). Essentially, the government is encouraging the R&D in battery-related and smart car technologies. A call is made for long-term and stable supporting funds for the NEV sector that should promote research, testing, and application for the new technologies (The State Council of the People's Republic of China, 2014). Furthermore, the end-goal of such innovation driven development is raising the technological standards by means of driving range, energy consumption and power battery density in the NEVs (Ministry of Finance et al., 2019). Once again, the existence of a new approach in the Chinese state's attitude in respect to the automotive industry is obvious. Technological innovation is designated as main driving force of the industry, based on *independent* intellectual property (The State Council of the People's Republic of China, 2012). This new attitude is contrasting with the early years of the ICEV Chinese development, under Mao, when the state alone had taken the responsibility of kick-starting the industry. Realising that money alone does not buy you success in the automotive industry, this fresh start gave the opportunity to the Chinese state of rely on an innovation network with market dynamics, away from the traditional hierarchy of the classic Developmental State.

Supporting the argument of the innovation-driven development, new independent investment projects targeted at pure electric vehicles should own intellectual property rights in core NEV technologies. Moreover, they should have established R&D offices with teams capable of designing, testing and developing core systems and structures of pure electric vehicles (State Development & Reform Commission, 2018, Art. 18). Even though the initial fears related to the industrial fragmentation encouraged the formation of a few leading enterprises (The State Council of the People's Republic of China, 2012), it has been realised that every new player capable of innovating is relevant for the overall industrial development. The shift from pure economic growth generated by production capacity towards innovation in the developmental state mindset is clearly translated even at this micro level where investors are bound to own patents in relevant technologies.

One last aspect highlighted in the governmental agenda related to the development of the NEV sector is battery recycling, to the extent of publishing an official document on *Organizing and Launching the Pilot Program of Recycling Traction Batteries of New Energy Vehicles*. It is called for the adoption of a circular economy perspective when it comes to NEV batteries,

using technologies such as IoT for monitoring the product lifecycle. The responsibility for battery recycling should be shared between vehicle producers, battery producers, waste vehicle recycling and dismantling enterprises, aiming for *a mode of innovative commercial cooperation in recycling traction batteries* (Ministry of Industry & Information Technology, Ministry of Science & Technology and Ministry of Environmental Protection, 2018). The traceability of the batteries is elementary for a *complete industrial support system*, and in this sense clear responsibilities of the industrial actors are formulated (The State Council of the People's Republic of China, 2012). The battery recycling processes include second use, renewal and disposal capabilities (State Development & Reform Commission, 2018, Art. 9). The Chinese state is proving to have realised the fact that a healthy and efficient industrial management involves clear directions, compared to the vague industrial planning that the domestic automotive industry was subjected to before the 1990s. Furthermore, it has to be mentioned that the focus put by the Chinese actors on battery recycling in both official documents and media articles has been rather surprising.

Clearly, the Chinese government has conducted thorough studies in respect to what the full picture of the NEV sector entails prior to launching the boat to the sea. The conclusions consisted in a well-developed charging infrastructure working in tandem with the vehicle core technology advancements, and battery recycling regulations that would provide a sustainable development of the first two. The surprise in respect to the battery recycling focus is that it is not necessarily a determinant factor for the commercial success of NEVs at this moment in time. Contrarily, it is a preoccupation related to the long-term effects of the NEV sector. This shows a comprehensive and responsible understanding of the NEV phenomenon by the policymakers.

5.2. Core technologies and their innovation networks

In order to trace down the NEV innovation networks, nine patent mining sessions have been conducted, from which eight of them are using specific key words designating core NEV technologies. The only exception has been the network using the "new energy vehicle" key concept, which has also been the opening mining session. The network consists in 12.897 patents, from which, an outstanding majority is owned by Chinese actors. The incontestable dominance of the Chinese actors over this concept has been initially a surprise. However, it was later realised that such dynamic should have been expected, given that the term "new

energy vehicle" is mainly used in China and it has been coined by the Chinese policy makers in the national FYPs.

However, the other eight patent mining sessions have used narrowed down key words, trying to depict the innovation networks formed around various NEV-related technologies such as battery management systems (BMS), drive systems, electric motors, motor controllers, power battery, vehicle-to-grid (V2G), Internet of Things (IoT), and solid-state battery – in total, accounting for a few tens of thousands of patents. These eight key words have been chosen based on what the Chinese state identified as core technologies for the industry, on one hand, and on the other hand, based on technologies that are generally popular when it comes to NEVs (such as solid-state battery and V2G). After analysing the formed networks, it has been acknowledged the fact that three types of networks could be identified, based on the discovered dynamics. Namely, the largest cluster, which mainly consists in battery-related technologies and energy management systems, a second cluster, comprised of electric motor and driving systems, and the third one which is represented by solid-state battery.

Each cluster is demonstrating a certain type of technology. The first one is arguably the most important for NEVs, under the current configuration of the supply chain. It stands for the present lithium-ion battery technology, together with its related technologies for battery management and charging. In these networks it can be observed a great dominance of the Chinese actors by means of patent ownership and interconnectivity. All three types of Chinese actors are present in the centrality tops – i.e. SOEs, private enterprises and academic institutions. The second cluster is formed by two interrelated technologies. Motor drive systems are the technologies determining starting, accelerating, climbing and other driving conditions related to the vehicle's motion (Cai Chi-lan et al., 2011). The centrality tops of these two networks unveil a slightly different dynamic compared to the first cluster. The Chinese actors are concentrated at the back of the tops, while foreign actors from South Korea, Japan and the United States are holding onto the first positions. Lastly, the third cluster is embodied by the future technology. Solid-state batteries are believed to be the next major technology that will replace the lithium-ion batteries within the next decade.

It is essential to mention that there is no production vehicle currently available using such technology. Many relevant actors within the automotive industry are focusing R&D resources in this direction, however, there is no stable solid-state battery to date, nor are there the required related battery management technologies. This network is of great peculiarity given the

characteristics of the technology. The top 20 of centrality includes only one Chinese actor, and that is the Chinese Academy of Sciences (CAS), while the undisputed dominant actor of the network is the Japanese Toyota.

5.2.1. Network patterns

After analysing the networks compiled in the three clusters, some patterns have been depicted in relation with the type of technology and the degree of centrality held by the Chinese actors in the associated networks. In *Table 1*, these patterns can be observed under the form of a 2x2 matrix. The rows of the matrix are determining the type of research associated with a given technology, namely basic or applied, where *basic* represents an early, experimental stage in the development of the technology, and *applied* determines a palpable, market-available, stage in the technological R&D. The columns of the matrix are describing the distance between the Chinese actors and the innovation frontline of a given technology. A short distance is represented in the network with an extended presence of Chinese actors in the centrality tops, while a long distance is characterised by either their absence or marginality.

Table 1 - Patterns of innovation networks (Source: Author)

	Short	*Long*
Basic	–	Solid-state battery
Applied	Li-ion battery-related technologies (plus motor controller technologies)	E-motor and driving systems

The following paragraphs will provide the analysis and Gephi visualisation of representative networks for each of the three depicted clusters. The networks selected for visualisation are the most illustrative for their clusters. All other visualisations that have not been included in the main body of text will be available in the thesis' appendix. The visualisations are portraying the top 20 clusters in each network, so that a better visibility of the network dynamics is showcased. No network has been identified as part of both basic research and short distance groups, proving that the Chinese actors are dominating networks of stable technologies, which can be translated quickly to the market. In this sense, the innovation networks related to li-ion battery technologies unveil a very interesting characteristic. All these networks are demonstrating a constant dominance of State Grid Corporation in terms of centrality. In most top positions of these networks, SOEs are leading the environment, while

the only persistent private actors are BYD and Geely. In this network configuration, SOEs are displaying, in multiple instances, shared patent ownership with either universities, research institutes, or other SOEs. Private actors are rather isolated within the innovation networks when it comes to collaborating with other actors, with only a few exceptions.

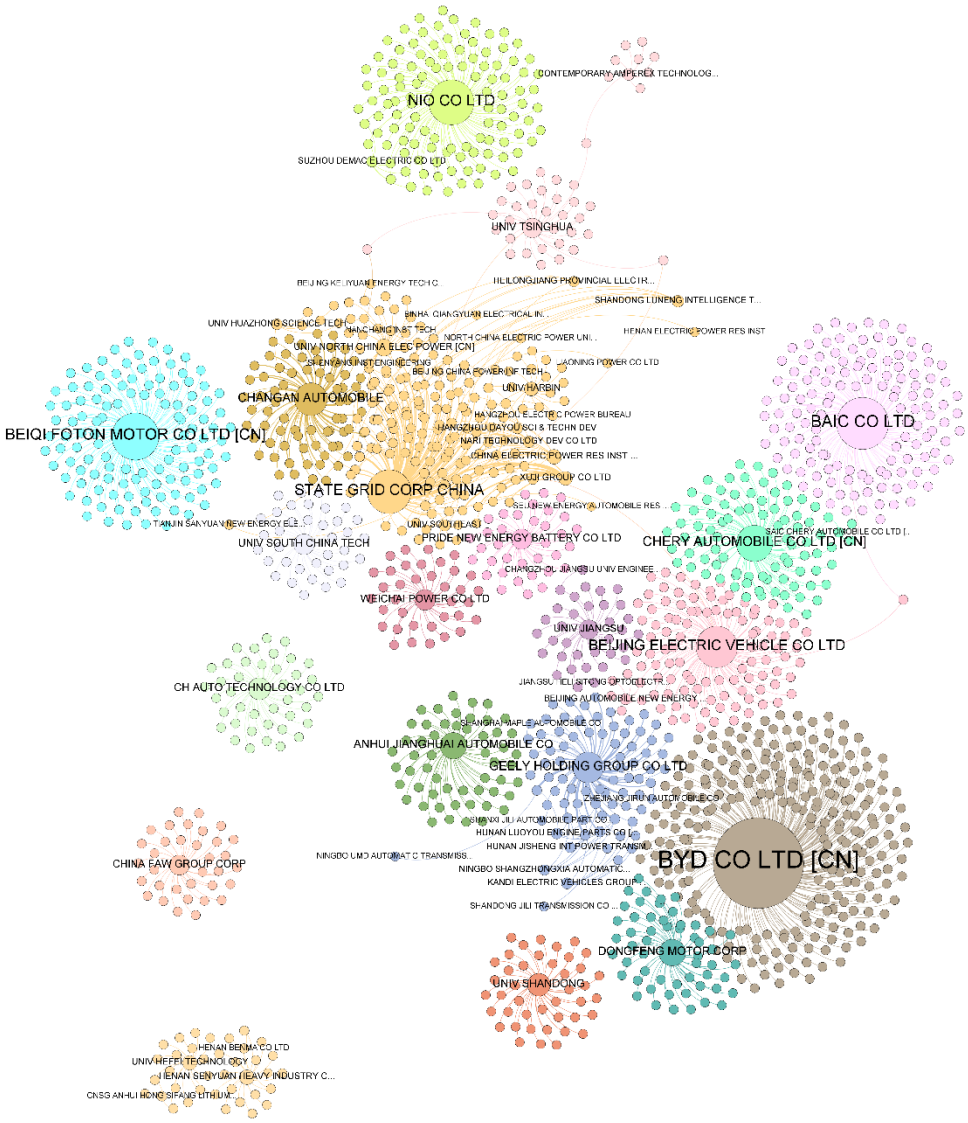


Fig. 2 – The network formed around the key concept "power battery" based on the actors' patent ownership. (Source: Author)

The network illustrated in *Fig. 2* displays a high centrality of three private actors, BYD, Geely and NIO. BYD, the leader of the network does not have any shared patent ownerships in this network, providing a great example for the isolation trend experienced by the private actors in the innovation networks. On the state-owned side, the major actors are State Grid,

BAIC, and Changan Automobile. State Grid is visibly engaging a lot of other actors, from subsidiaries such as Xuji Group and Nari Technology to universities such as North China Electric Power University, Harbin Engineering University and Tsinghua University. Tsinghua University is a perfect model for portraying the role of the academic actor in the innovation network. It shares patent ownership with State Grid and Changan Automobile, highlighting the strong relationship between SOEs and universities. On the other hand, it also has patents developed by itself, without collaborating with industrial actors. Furthermore, Tsinghua University exhibits a peculiar phenomenon, engaging in patent ownership also with Contemporary Amperex, which is a private company. Such phenomenon has been deemed as unlikely by the general results of the findings.

The "power battery" innovation network top is dominated exclusively by Chinese actors. No non-Chinese actor is central to this network. The strong interconnectivity portrayed in the battery related technologies' networks arguments in the favour of the used Triple Helix Model. Namely, the triad state-industry-academia is clearly visible. The state offers the regulatory framework for innovation, while the SOEs develop technologies in collaboration with universities and research institutes. Moreover, Chinese universities and research institutes are clearly having prominent roles in the analysed networks, holding patent ownership both alone and in collaboration with SOEs.

Nevertheless, it is also interesting to observe how the innovation network looks on the other side of the used theoretical model. Given that the private actors appear as isolated in the analysed networks, how do they manage to innovate? On one hand, private actors have developed strong in-house R&D capabilities, relying in most cases on their own innovation output. On the other hand, the private actors tend to leapfrog by interacting with foreign actors under various forms. Even though none of the above private actor phenomena were visible through social network analysis, they were unveiled during the analysis of the media sources. Observing the degree of centrality held by various actors, I was puzzled by the constant presence of BYD and Geely in the top 10 leading positions. A possible explanation is precisely the interaction with the foreign actors. In the past, SOEs used to collaborate with foreign companies by forming joint ventures. Now, private actors are cooperating with foreign companies in order to compensate for the limited – or even lacking – contact with the academic sector.

Geely has acquired Volvo, Lotus, Terrafugia, and purchased 9.7% shares in Daimler AG, and that only since 2010 (Xinhua News Agency, 2018a). BYD has received major investments from Berkshire Hathaway, Samsung and Daimler (Xinhua News Agency, 2018b). Wanxiang Group has acquired Karma Automotive and A123Systems (Xinhua News Agency, 2014). And a less known example is Evergrande Group, which procured National Electric Vehicle Sweden (NEVS) – the owner of the Swedish manufacturer Saab – (Hampel, 2019b), as well as shares in Koenigsegg (Petrány, 2019) and Faraday Future (O'Kane, 2019). There are similar interactions between SOEs or Chinese universities and foreign actors, but more as an additional way of stimulating innovation. Nevertheless, these do not seem to contour a dominant strategy as compared to the private actors' case. Some examples in this respect are

Fig. 3 – The network formed around the key concept "solid-state battery" based on the actors' patent ownership. (Source: Author)

the investment made by Tsing Capital – a fund management company under Tsinghua University – in Lucid Motors (Vijayenthiran, 2019), and Dongfeng's investment in PSA Groupe (Reuters, 2020).

At the other extreme of the innovation networks' patterns, solid-state battery technologies can be found, illustrated in *Fig.3*. This is a new, unstable, technology that is still at the stage of basic research in the Chinese case. This technology is believed to come as a replacement for the li-ion batteries within the next decade. No actor of the global automotive industry seems to have reached the applied research stage in respect to solid-state batteries. Nonetheless, in the analysed innovation network the number one leading company is Toyota, the same company

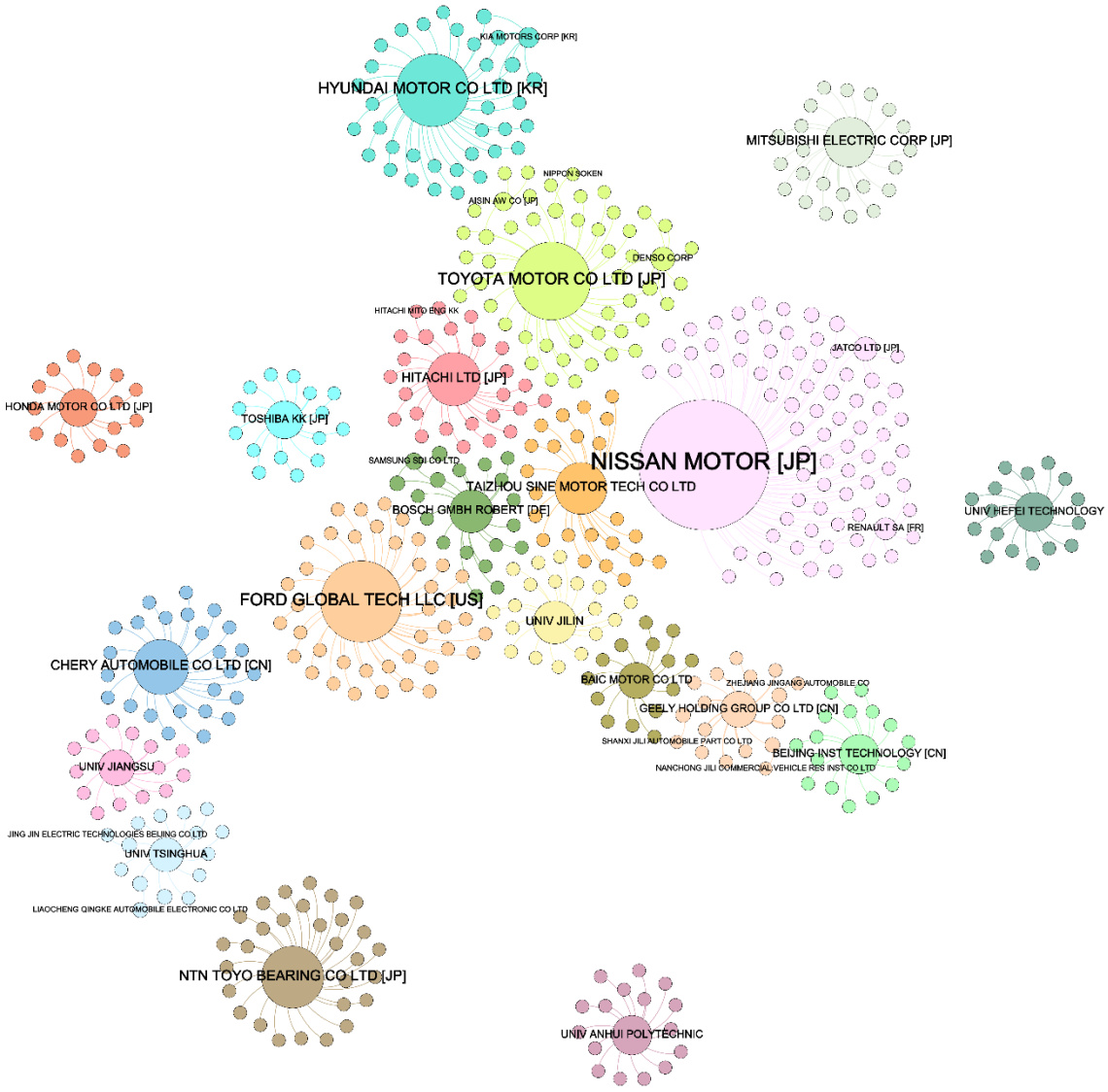


Fig. 4 – The network formed around the key concept "drive system" based on the actors' patent ownership. (Source: Author)

that introduced the first production hybrid electric vehicle in the late 1990s, the Prius. In this network, the Chinese presence is marginally expressed through the Chinese Academy of Sciences, with no other actor present in the centrality tops. This network type showcases a greater diversity in terms of country representativity. Nonetheless, the Japanese actors are the most prominent, replicating the dynamics observed in the Chinese dominated networks.

Between the two extremes of basic research – long distance, and applied research – short distance, the cluster including E-motor and driving system technologies emerges under the groups of applied research and long distance, shown in *Fig. 4*. This pattern is also characterised by a great presence of Chinese actors, but most of them are concentrated at the back of the centrality tops, and non-Chinese automotive giants such as Hyundai, Toyota and Ford are leading the innovation network. The only Chinese exceptions in the centrality tops by individual actors are Chery and Geely in the drive systems' network, and BYD and State Grid Corporation in the e-motor's network. Such results suggest the trend of a Chinese catch-up, where the Chinese innovation will eventually reach the applied research – short distance stage at some point in the future. This fact is further supported by the Chinese dominance of the *motor controller* network, which is a technology related directly to e-motors and drive systems. It can be observed that the network illustrated in *Fig. 4* demonstrates a great presence of Chinese academic actors, thus highlighting the already observed pattern of increased academic importance within the catching-up phases, similar to the solid-state battery network. After comprehensively analysing these patterns, the presence of State Grid and CAS has appeared as highly relevant for the overall understanding of the Chinese innovation network and, implicitly, of the new role possessed by the Chinese state at the technological frontier.

5.3. Why are SGCC and CAS important?

These two actors are the exponents of the Chinese innovation in opposite stages. State Grid Corporation, on one hand, is the perfect example of the new generation of Chinese SOE. Namely, it is the result of the state-driven market creation strategy, where the market is reflected through multi-layered profit-driven state actors (Wang, 2015). On the other hand, CAS is the Chinese *brain bank*, strongly guided by meritocracy, experiencing a certain degree of autonomy in relation to the state, providing scientific guidance to the political elite, and academically leading the society (Cao and Suttmeier, 1999). CAS is not a simple academic actor in the current context of an extended governmental focus on *scientificity* in decision making (Li, Yang and Xiao, 2016). In this sense, the institution's activity with respect to solid-

state battery technologies might be targeted at unveiling the full implications of such new technological framework if applied to the Chinese automotive industry. The appearances of State Grid and CAS in certain innovation networks describe opposite ends of the Chinese innovation process. Namely, the development starts with basic research, which is purely scientific and has no translation onto the market, thus, academic actors are having an extensive role. Once the technology is stabilised, the industrial actors convert innovation to the market, while still maintaining a strong relationship with universities and research institutes for further technological modifications. This whole process is taking place on the managerial premises of the government, providing the right amount of market dynamics and facilitating the interaction between industry-academia.

In addition, State Grid Corporation is a peculiar actor of the Chinese innovation network compared to other actors of the global automotive industry. One must acknowledge the fact that SGCC's primary role is that of national electric utility monopoly. Since the governmental focus has shifted towards the NEV sector, SGCC has taken active roles in building charging infrastructure and organising industrial alliances between various actors of the automotive industry (Hampel, 2019a). As a parallel with the ICEV paradigm, imagine a state-owned version of Royal Dutch Shell which also plays a vital role in the innovation process of internal combustion engines. Such actor has never existed before. It is the ideally state-designed tool for innovation marketisation. Charging infrastructure is playing a determinant role in the NEV development, as highlighted by the official documents through the *pile station first* principle. Having a high density of charging piles is a difficult task to achieve in many countries because such infrastructural project implies taking great risks. That is one of the arguments for which the role of a state-owned actor such as State Grid is crucial in this paradigm. It has been surprising to observe that SGCC's presence is not limited to the *food chain* of the lithium-ion battery. For example, it appears in one of the prominent clusters of the motor controller network, together with Tsinghua University, it also occupies an important position in the centrality top of the e-motor network, and it even appears with 11 patents in the drive system network. Furthermore, it was discovered that SGCC is not limited to industrial assets. Besides the subsidiary research institutes, it holds a leading position in the council of North China Electric Power University (China Daily, 2018).

6. Conclusion

In the introduction of this paper, I highlighted the importance of the automotive industry on the global economic arena, with an exceptional attention for the Chinese context. Such extended importance was explained through its great engagement of downstream and upstream industries, as well as through the mere nature of the end-product, which is an expensive commodity and part of the daily lives of many citizens. Consequently, the automotive industry is used as an exponent for the Chinese economic system and for its innovation dynamics. Nonetheless, the automotive industry's global transition towards the NEV sector brings this highly complex industry to the technological frontier. Based on the conducted analysis, it has been found out that the Chinese industrial paradigm has changed once the NEV sector reached the governmental spotlight. This change has both ideological and practical implications.

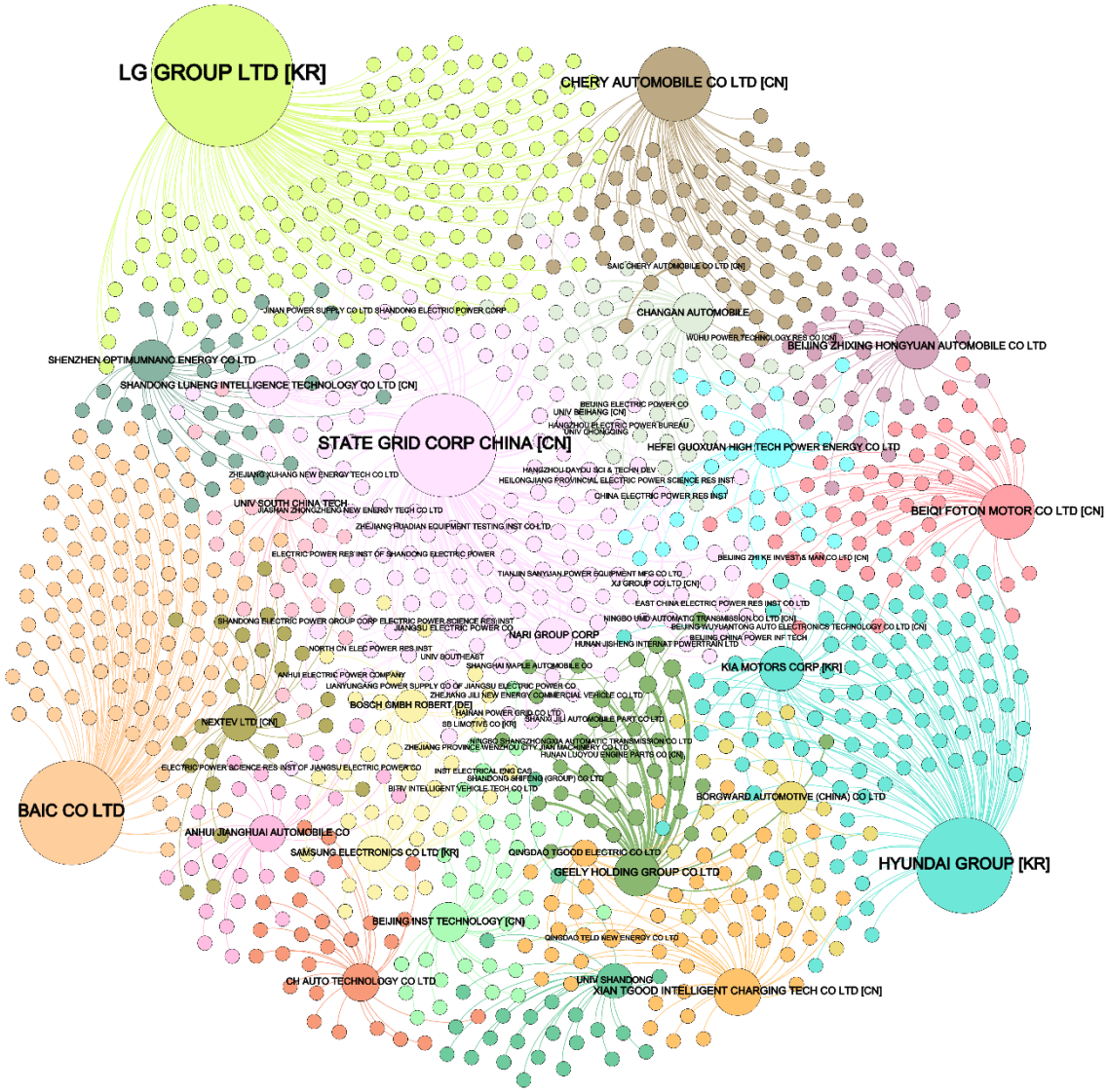
The key features of this new phase are, on one hand, the shift from a production-driven automotive industry, to an innovation-driven one. The process of innovation is conducted domestically and based on autochthonous resources, and the relationship with foreign actors undoubtedly witnesses new trends, given that the role of joint ventures is drastically diminished. On the other hand, the industrial environment's structure shifts away from a hierarchical configuration towards an interconnected network, where each actor holds important roles. The state, in this system, is not an overly protective parent anymore, that dictates the landscape. Contrarily, it becomes a manager of the whole network, facilitating the interaction between all actors in the network and mediating the coexistence between the two present spheres, i.e. state-SOE-university and state-private-foreign. The Chinese state has redesigned its role in the context of the *Knowledge Society* by making use of the market dynamics. The power of the market is carefully injected in this peculiar version of the centralised economic system, fixing its inefficiencies and weaknesses. The market should punish and eliminate naturally the actors that are unable to innovate.

The NEV sector represents a fresh start for the Chinese industry, where the domestic actors can finally compete one-to-one with foreign actors, and the innovation stakes are much higher than in the ICEV setting. In this sense, it has been realised that policy makers cannot *produce* innovation by the same means they would have stimulated production capacity in the past. However, they can *encourage* it by organising an appropriate industrial environment. The new Developmental State model proposed in this paper is not a transitional period as the traditional model suggested. It is a sustainable system which obtains legitimacy precisely

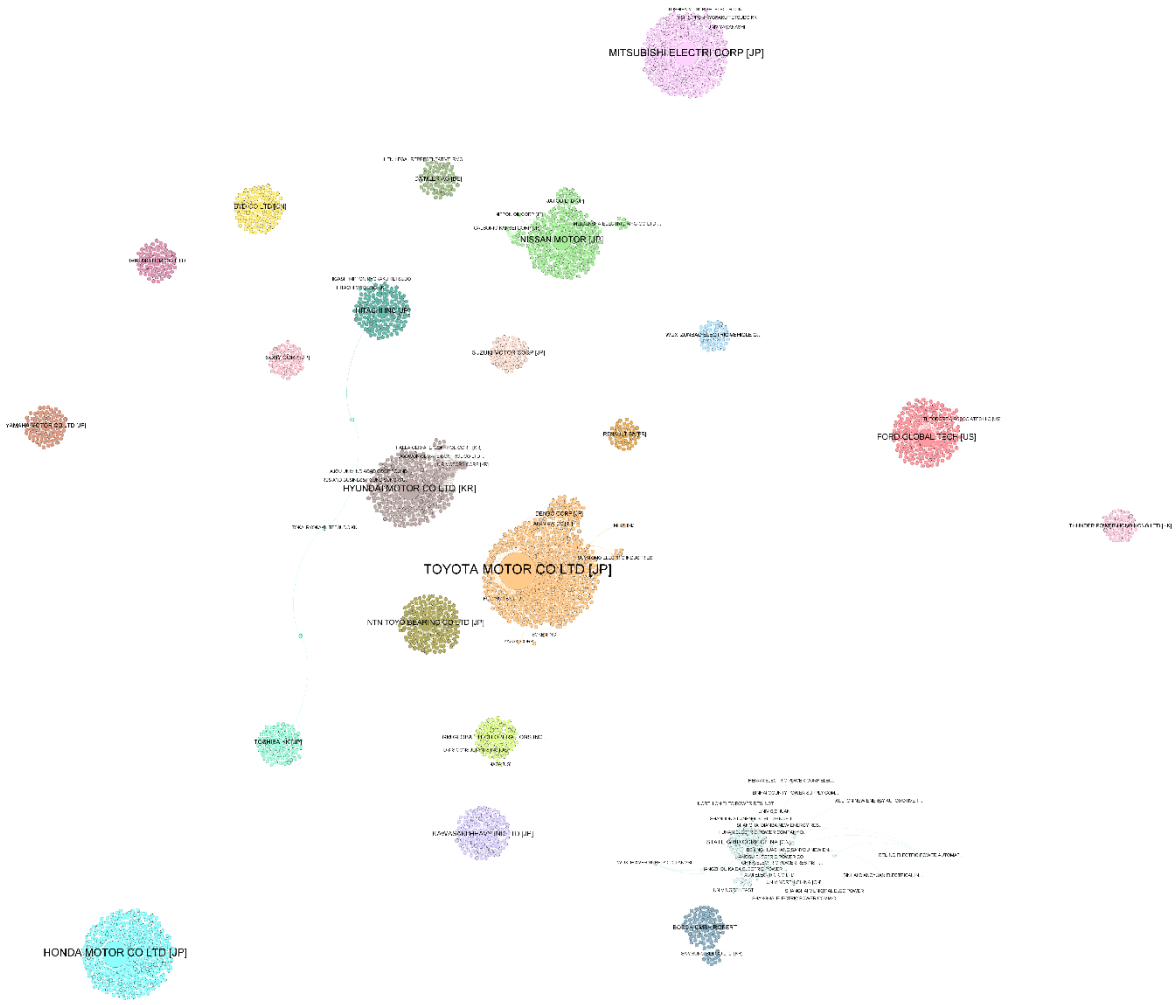
through innovation, as opposed to economic growth, and which thrives at the technological frontier. The innovation network is structured in two spheres that interact through the state node. Both spheres illustrate the policy-economy-academia paradigm, but under different forms. First, the state-SOE-university sphere can be observed, where the interaction between industry-academia is guaranteed by the fact that they both operate under the governmental *shareholdership*. Second, the state-private-foreign sphere has emerged as a landmark of the paradigm shift. The private actors secure an important role under the innovation-driven model and compensate for the limited access to university collaborations through interactions involving foreign actors either inbound or outbound. Even though the two spheres differ in terms of duty disposition between the involved actors, they are building together a balanced industrial network of innovation, with the state at its centre.

This new industrial context also showcases a set of innovation patterns contoured around the positions of various NEV technologies. It has been observed how key actors are deployed by the state depending on the research stage. Namely, it was depicted how academic institutions such as CAS play a relevant role for technologies that are still undergoing basic research and which, implicitly, are incompatible with a mass production implementation. At the other end, the importance of State Grid Corporation has been observed in the case of technologies that are, to a certain extent, mastered, and have immediate applicability onto the market. The SGCC is a clear example of the new paradigm. Precisely, a state-owned enterprise that enjoys a specific amount of autonomy, operates under a commercial mindset, and also respects the state issued targets. This phenomenon should be subjected to further research in order to get a clearer understanding of the practical roles possessed by actors like SGCC. Furthermore, the newly proposed variant of the Developmental State should be additionally validated through the empirical analysis of other core Chinese industries that situate at the technological frontier.

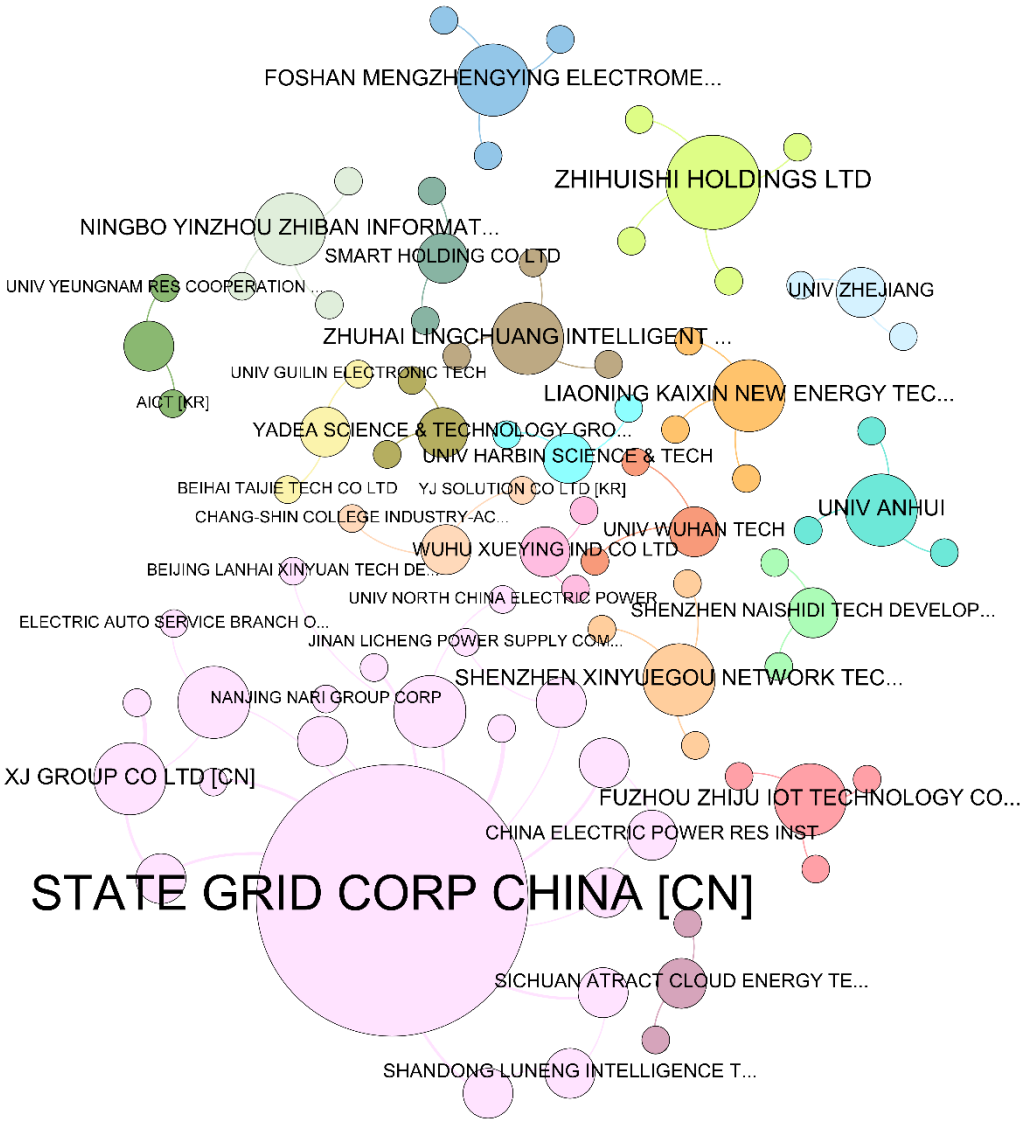
Appendix – Additional network visualisations



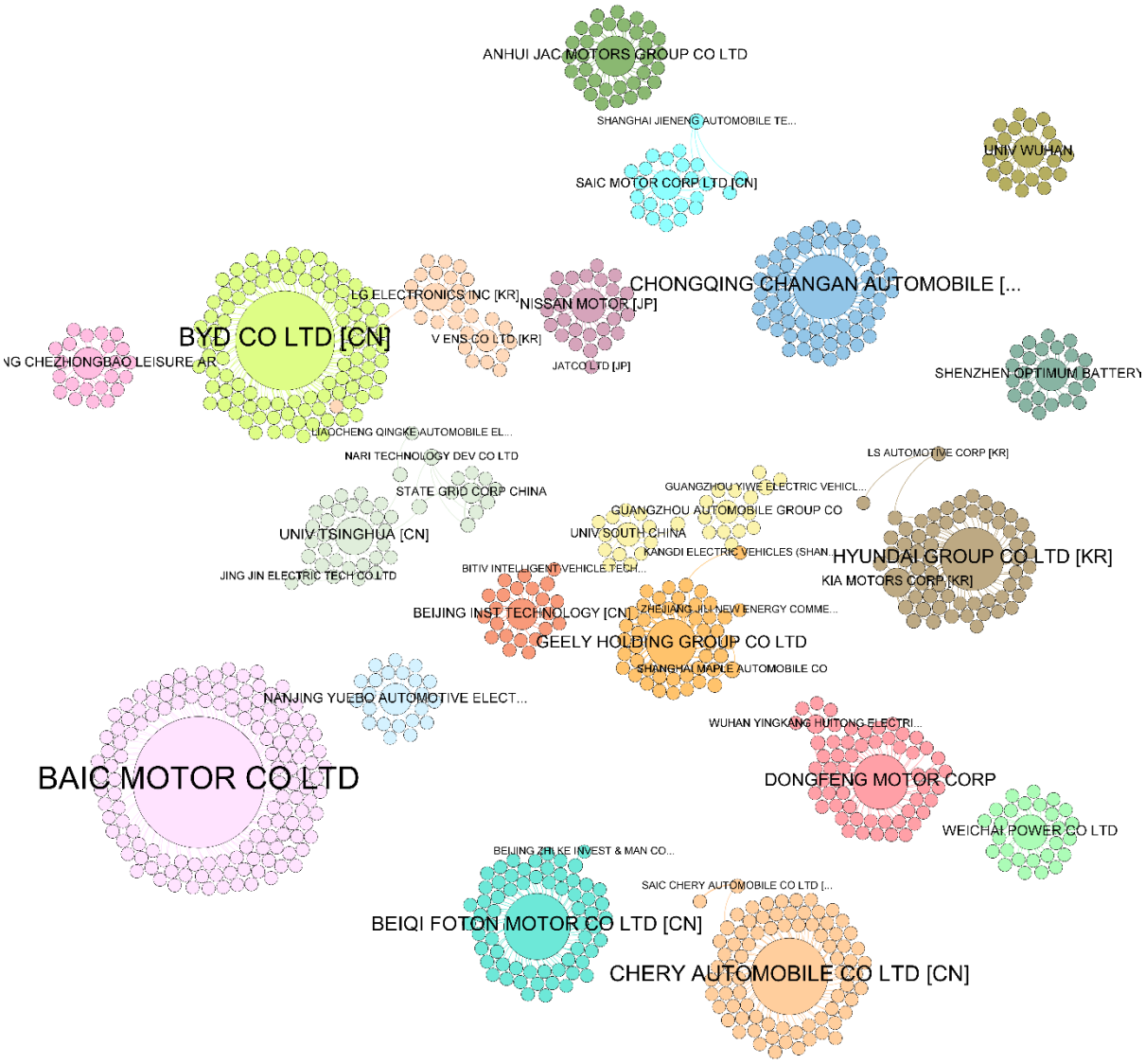
The network formed around the key concept "battery management system" based on the actors' patent ownership. (Source: Author)



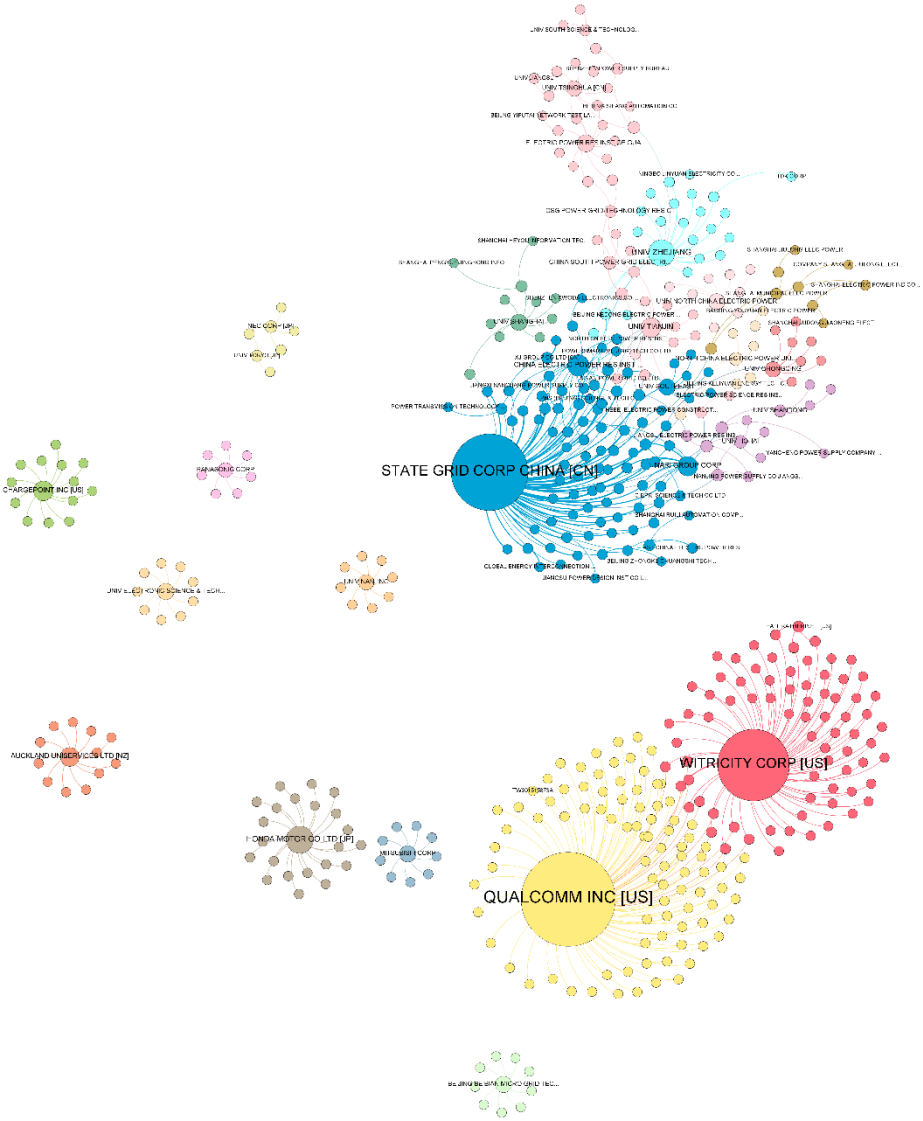
The network formed around the key concept "electric motor" based on the actors' patent ownership. (Source: Author)



The network formed around the key concept "Internet of Things" based on the actors' patent ownership. (Source: Author)



The network formed around the key concept "motor controller" based on the actors' patent ownership. (Source: Author)



The network formed around the key concept "vehicle-to-grid" based on the actors' patent ownership. (Source: Author)

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