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Article

Barriers to Constructing New Energy Vehicles According to Chinese SMEs

Qiuyu GaoYan [1], Darren McCauley [2] and Natalia Konina [3,*]

[1] Graduate student of National Research University and Johns Hopkins University; qgaoyan1@jhu.edu
[2] University of St.Andrews, Irvine Building, North Street, St Andrews, Fife, KY16 9AL, Scotland, UK; dam7@st-andrews.ac.uk
[3] Moscow State University of International Relations (MGIMO University); nkonina777@gmail.com
* Correspondence: nkonina777@gmail.com; Tel.: +7(495)234-84-57

Abstract: New energy vehicles (NEVs) have been proposed as a promising technology to reduce greenhouse gas (GHG) emissions. China is one of the leading countries in the development of NEVs, and a wide range of companies, including large and smaller businesses, are involved in the Chinese NEV market. Given that the NEV market involves the creation of nascent technologies, there are significant barriers to the development of NEV companies in the business growth stage. This is particularly significant in the case of small and medium-sized enterprises (SMEs). This study surveyed 100 NEV SMEs in China using a structured questionnaire to determine the most significant barriers to the growth of their businesses. Calculating the relative importance index (RII) from the collected questionnaire responses revealed that the most significant barrier at the growth stage is the lack of skilled scientists in China. The most important category of barriers is legal and institutional barriers, which suggests that government intervention in business activities, taxes, and unclear regulations are viewed by entrepreneurs as a serous hindrance to further development in the NEV industry.

Keywords: cars; China; climate change; innovation; renewables

1. Introduction

1.1. Background

New energy vehicles (NEVs) are powered by sustainable sources such as electricity rather than the combustible fuel used in traditional vehicles. NEVs have been recommended as alternatives to traditional vehicles as a result of the increasing acceptance of the role played by human activity in causing climate change. Of the human activities that have a significant impact on the environment, vehicular emissions that arise from the need for transportation are a significant contributor; an estimated 26% of global carbon dioxide (CO_2) emissions are attributed to transportation, including the use of cars, road freight, and aviation [1]. Further, developing countries have witnessed strong growth in domestic demand for motorization in recent years. As a result, the potential increase in the number of private vehicles added to the roads in the world will be likely to overwhelm the benefits to be gained from the use of cleaner fuels. This suggests that a range of measures need to be applied to reduce greenhouse gas (GHG) emissions [2]. NEVs are thus a promising measure to reduce GHGs and have been proposed as a solution to reducing air pollution in countries such as China [3]. NEVs show promise for a country like China for several reasons. First, given enough demand, a move towards partial or fully electric powered vehicles could reduce a country's dependence on petroleum imports. This is particularly significant for a country like China, which is a net crude oil importer. Second, China already suffers significantly from air pollution and the use of NEVs could significantly militate against this [4].

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1.2 Research question and justification

The research question that this dissertation aims to answer is "What are the barriers to further development of new energy vehicle (NEV) small and medium-sized enterprises (SMEs) in China at the growth stage?" There are several reasons why NEVs are interesting. First, as noted above, any moves towards partial or fully electric powered vehicles have the potential to reduce the country's dependence on petroleum imports. This increases energy security for a net importer like China. Second, internal combustion engines emit pollution, and China already suffers from severe air pollution due to the country's recent history vis-à-vis its industrial development trajectory. Thus, NEVs can shift China towards a more sustainable development model while reducing the country's contribution to global climate change. An answer to this research question is also especially timely given that the Chinese government has initiated programs such as the "Thousands of Vehicles, Tens of Cities" to increase NEV commercialization [3]. This investigation could therefore shed some light on whether the government's efforts have thus far been successful and provide some policy guidance on the measures that need to be implemented or adjusted to increase the adoption rate of NEVs.

1.3 Research justification

China's NEV industry is nascent; as a result, there have been relatively few studies conducted on the NEV industry in that country. Gong *et al.*'s study on the Chinese NEV market [3], as an example, focuses on the policymaker level and is largely descriptive in nature. Kimble and Wang conducted a survey in the NEV market domain [5], and the innovation in that industry. Again, this study takes a, largely, descriptive quantitative approach to eliciting, delineating and exploring the barriers to growth in NEV SMEs. While prior studies have focused on government policies or industry-level developments, this study directly solicits the opinions of entrepreneurs in the industry. This approach therefore allows this study to bridge the gap between the higher-level studies that have been conducted in the past, and to identify the extent to which policies formulated at these higher levels have been implemented on the ground.

1.4 Article structure

Section 2 provides a background to the climate change problem and the significance of NEVs to the mitigation dilemma. Section 3 offers a comprehensive literature review on the policy aspects of climate change and the role of the new energy sector and NEV industry in China. Next, Section 4 describes the methodology used in this study to answer the research question with empirical results delineated and explored in Section 5. Implications of the findings are discussed in Section 6 before, finally, Section 7 concludes the study by offering salient policy recommendations, reflecting on limitations, and makes suggestions for future research.

2. Literature Review

2.1 The role of energy in the global economy and the imperative for a clean energy transition

Since the 18th century, the energy sector has played an instrumental role in raising the standard of living around the world. It is also the largest sector, with an economic value of USD $9 trillion, dwarfing all other global industries [6] (p. 5). Further, the energy sector also provides a vital input into all other industries.

Notwithstanding the central importance of energy to human activity, the growing consumption of energy has come at a price. Combustion of natural resources for energy has led to increased GHG emissions which are linked to adverse climate effects. Deleterious climate events could lead to catastrophic outcomes including mass crop failures and droughts such that the human race could face extinction within a century [7].

In essence, shifting to cleaner energy is a matter of survival for the human race. There are significant economic challenges in shifting to a new energy infrastructure, as considerable resources

have been sunk into the development of the current system. This transition is not expected to be easy or predictable in many respects, creating important environmental and economic uncertainties.

2.2 Climate change, international policy responses, and new energy sources

Anthropogenic activities such as agriculture and the combustion of fossil fuels have been unequivocally implicated in climate change. Internationally, the debate on climate change over the past four decades has increasingly gained worldwide attention [8]. While a number of treaties and agreements have been agreed upon in the past such as the Kyoto Protocol (ratified in 2005), the first universal legally binding global climate deal was signed in Paris 2015. The Paris Agreement's aim was to develop a global action plan to avoid catastrophic climate change by limiting global warming to 2 degrees Celsius above pre-industrial levels by 2050.

The key focus of the Paris Agreement is on the use of "new energy," or energy derived from renewable resources such as wind, the sun, and water. The most important challenges that need to be overcome to ensure the uptake and success of new energy across the world are economic, e.g., to reduce the unit price of new energy so that it is economically viable to deploy renewable energy technologies. The economic costs of transitioning to a sustainable economy also need to be considered carefully. There is no doubt a cost involved in upgrading the energy infrastructure to be driven by new energy sources; this cost could amount to 5.5% of global GDP by 2050 which would slow global GDP growth by 3.4% [9]. However, there are phenomenal market and non-market costs associated with delaying this transition or worse, maintaining the status quo; the OECD estimated that delay could reduce global GDP per capita by 14% [9].

2.3 Costs and benefits of new energy

While traditional fossil fuel energy sources are more affordable than new energy sources at present, there is the potential for this to change in future as a consequence of innovation and harnessing economies of scale and scope. The development and commercialization of new energy can potentially provide energy to regions that would not otherwise be possible with the current inefficient infrastructure. The use of new energy can also mitigate some of the negative environmental impacts that have been driven by large scale urbanization.

2.4 China's energy sector

China's economy has been growing rapidly over recent decades which, unfortunately, has also led to China being the largest emitter of greenhouse gases [10]. As a result of this, the Chinese government has realized that its current economic model is unsustainable and has developed the so-called "new normal" focused on higher quality growth of around 7% per year which is socially and environmental sustainable [11]. Under this framework, there will be specific measures taken to reduce air pollution [12].

China, however, will need to take into account its resource constraints when steering its new normal framework. The available evidence suggests that China still relies heavily on fossil fuels. As of 2014, renewable energy is only 9% of China's energy mix. Sixty-six percent and twenty percent of the energy used in China is generated by coal and oil respectively, and dependence on imported oil and gas is expected to increase by at least 50% by 2030 [11]. Nevertheless, as part of the new normal developmental framework, China plans to increase its share of non-fossil fuels in the energy mix to 20% by 2030 [13]. There is some evidence that China has been moving towards this goal, as its renewable energy share of 9% in 2014 represents a substantial increase compared to the turn of the 21st century. Further, in 2014 itself, China installed 70 GW of additional non-coal electrical generation capacity and 53 GW of new energy projects including solar plants, hydroelectric dams, and wind farms [14].With a new energy based infrastructure, it may be possible to allow for a de-urbanization process to ensue as new energy would allow individuals to move to rural areas and yet have sufficient access to cheap and abundant energy and transportation [15].

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2.5 Changes and innovation in China's energy sector in the 21st Century

In the past five years, there has been a surge of investment in China's renewable energy sector. In 2010, China's investment in this sector eclipsed major North American and European markets. For many new technologies such as those associated with wind, energy and nuclear, China is seen as the prime global market. In 2009 China became the largest market for NEVs [3]. The development of the NEV market in China has been driven by several factors including the growing industrialization of the country and rising incomes which had led China to become the fastest growing market for vehicles in the world. The Chinese government had also seized upon developing the NEV market as a potential solution to air pollution problems. Since there is still relatively low vehicle ownership in China, there are opportunities to reduce, or even reverse, the environmental damage in China by introducing NEVs to reduce emissions [16].

The NEV industry is still in a nascent stage and there will likely need to be significant development in the industry before it represents a viable alternative to conventional vehicles. To differentiate themselves from their competitors, many Chinese vehicle manufacturers have also instituted R&D programs to improve their NEV offerings [17]. The Chinese government has also pursued several policy initiatives to boost the NEV industry. These measures have included providing financial support for research and development of NEVs, providing subsidies to purchasers of NEVs to encourage their adoption, as well as other generous tax and investment policies to help offset some of the costs of developing these technologies [18].

This dissertation focuses on Chinese NEV SMEs in the growth phase of their development as described in Churchill and Lewis (1983) [19]—the company should already have been established and has survived the early stages of development to achieve some measure of success. The company thus needs to figure out ways to maintain performance into the future; for instance, whether to exploit new opportunities in the market or to keep the company stable and profitable in its current operating domain.

3. Methodology

3.1 Data collection

Opinions vis-à-vis the nature, scope and importance of barriers in the NEV market are elicited from SME entrepreneurs in China using a structured questionnaire. To meet this objective a hybrid availability-snowball sampling methodology is employed to identify respondents. The first wave of individuals targeted in this study are known to the researcher and these respondents then provide the basis for identifying a larger sample in the second wave.

3.2 Data analysis

Data from the questionnaires will be analyzed using the relative importance index (RII) used in and Xie et al. (2010) [20] Zeng et al. (2005) [21]. Respondents are asked to consider a list of barriers and rank them in order of importance on a scale of 1 to 5 where 1 represents the least important factor while 5 represents the most important factor. The RII takes values between 0 and 1 and is calculated as follows:

$$RII = (\sum \boldsymbol{\omega}) \Big/ A \times N$$

where a score between 1 and 5 as assigned by the respondent; *A* is the highest possible score in the study i.e., 5; and *N* is the total number of respondents.

3.3 Validity, reliability, and limitations

To ensure content validity, similar studies on innovation in SMEs were reviewed, including those pertaining to China, so that an exhaustive range of questions was included in the questionnaire. Similarly, construct validity was minded by designing a study broadly in line with previous studies on innovation in similar contexts. Since this study is largely exploratory in nature,

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there are few alternative instruments available for which criterion validity could be established, and thus this study makes no substantive claims in this regard.

One way to ensure reliability of the measures is to employ a test/retest methodology and evaluate discrepancies between the results suggested by both tests; a high test-retest correlation indicates that the results are reliable. This was not pursued herein because of time and resource constraints which precluded the possibility of a follow up study with the participants. Another method used to test for internal consistency is Cronbach's (1951) [22] alpha. Internal consistency is an estimate of reliability which groups questions on the basis of the concepts they are intended to capture and assesses whether the responses to intra-concept questions are consistent with one another. However, it was not possible to use this method herein because each barrier is approached by just one question in the survey instrument.

Other limitations of the data collected arise due to the sampling methodology and the exploratory nature of this study. The use of a non-probabilistic sampling methodology means that the results cannot be generalized to all Chinese NEV SMEs. This limits the scope of the conclusions that can be drawn from the study. Also, the exploratory nature of the study means that there is limited evidence from other studies that can be used to testify to the validity and reliability of any measures used herein.

4. Results

4.1 Respondents' Characteristics

A total of 120 initial responses were obtained from NEV SME entrepreneurs within two months of initial solicitation. Twenty of the responses were removed from the sample due to incomplete or invalid answer sets. Thus, data from a total of 100 respondents are available for analysis. Most of the entrepreneurs who responded to the study were relatively young: 23% of respondents were 20–30 years old; and 45% were 31–40. Befitting a technologically intense industry, 93% of surveyed entrepreneurs are educated to degree level or higher with a full 33% of the sample consisting of entrepreneurs with postgraduate (either Masters or PhD) degrees. Additionally, the majority of the employees in the companies represented by the surveyed entrepreneurs tended to be educated to at least degree level: 58% of respondents reported that at least 70% of their employees had undergraduate degrees or higher. The respondents to the survey were also overwhelmingly male (84%). Further, 39% were unmarried, 37% married without children, and 24% married with children. All of the entrepreneurs were already experienced with business and had run businesses in other sectors prior to being involved in the NEV industry. The most common industries previously experienced by the respondents were conventional energy (25%), real estate (23%), manufacturing (20%), and finance and consulting (17%). Interestingly, only 5% of respondents had previous experience with businesses in the automobile sector.

The companies run by the respondents were generally younger companies. Twenty-seven percent of respondents reported that their companies were between 1 to 3 years old, while 43% reported that they had been running the companies for between 3 to 5 years. The companies were generally small, with 12% of respondents reporting that they had fewer than 100 employees, 20% from 100 to 200 employees, and 28% of respondents from 200 to 300 employees. Nevertheless, the companies tended to have a significant amount of assets with 37% of respondents reporting that their business had assets of between 10 million to 25 million RMB; 28% of respondents reported assets of between 25 million and 50 million RMB. Start-up costs were also generally quite significant: 31% of entrepreneurs reported that it took between 1 million to 2 million RMB; while 54% provided figures indicating that the seed capital was 2 million RMB or more. This seed capital was mostly provided by commercial bank loans (47%) although self-financing (23%) and government bank loans (15%) were also significant sources of start-up capital. The most common reason given by respondents for starting their business in the NEV industry was "governmental incentives and subsidies" (45%), followed by "I have a patented technology and I want to commercialize it" (30%). "NEV is new to me but with a 'NEV' label, I could upgrade my original business model and achieve

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sustainable development" was a reason given by 15% of respondents, while 10% chose the NEV industry because it is a "strategic industry [with] promising prospects."

4.2 Analysis of barriers

Respondents were asked a number of questions aimed at determining the degree to which they perceived a range of factors to be significant barriers at the stage of business growth in part two of the questionnaire. The factors were presented based on several themes; specifically, the questions presented barriers to innovation based on financial, HR, market, legal, and institutional factors. The results were then collated and the RII was calculated for each of the responses. The results are summarized in Table 1.

Table 1. Subjectively elicited barriers to NEV SMEs: Descriptive Statistics and RII

Major barriers	Mean	Standard deviation	RII	Rank
Financial				
Commercial bank loans	2.320	0.909	0.464	28
Government loans	2.950	0.925	0.590	24
Issuing corporate bonds	4.310	0.907	0.862	8
Stock market	4.050	0.947	0.810	15
Venture capital	2.880	0.913	0.576	25
Private lending	2.110	0.984	0.422	30
HR				
Experienced accountants	2.740	1.070	0.548	26
Experienced lawyers	2.420	0.806	0.484	27
Efficient management team	3.050	0.903	0.610	22
Good salesmen	3.280	0.842	0.656	19
Public relations professionals	3.160	0.884	0.632	20
Employees with foreign language skills and global knowledge	4.160	0.735	0.832	13
Promising young scientists	4.720	0.451	0.944	1
Scientific support team	3.680	0.723	0.736	17
People with innovative ideas	4.280	0.712	0.856	10
Market				
Overcapacity in the industry	2.270	1.136	0.454	29
Battery range	4.290	0.640	0.858	9
Lack of national standards	3.530	0.904	0.706	18
Weak linkages with external markets	4.170	0.766	0.834	12

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Market acceptance and customer preferences	4.340	0.623	0.868	7
Lack of core technology and technology development strategy	4.220	0.675	0.844	11
Global economic recession or prosperity	4.020	0.710	0.804	16
Input cost and running cost compared to gasoline vehicles	4.140	0.739	0.828	14
Lack of charging infrastructure	4.380	0.582	0.876	6
Legal and institutional				
Insufficient government support	4.475	0.502	0.886	4
Lack of/or unclear regulations	4.636	0.483	0.918	2
Government intervenes in business activities	4.525	0.502	0.896	3
Numerous heavy taxes	4.465	0.501	0.884	5
Local market protection	3.061	0.956	0.606	23
Unfair competition	3.091	0.822	0.612	21

5. Discussion

5.1 Financial barriers

In industrial markets such as automobile manufacturing, financial factors have been considered to be one of the most significant barriers to entry. In a survey of industrial firms in the US, it was found that factors such as the capital required to enter markets, the capital intensity of the market, and the amount of sunk costs involved in entering the market represented highly significant barriers to entry [23]. The presence of financial barriers to entry makes it more difficult for potential market entrants to challenge incumbents where they do not have access to the resources necessary to secure market entry. This is particularly relevant in the case of SMEs because they typically require more external financing than larger firms as they tend to have insufficient cash flows to both sustain their current business and pursue growth objectives [24]. Importantly SMEs especially rely on external financing at the inception and growth phases [25].

Moving on, this study found that access to financial markets was one of the concerns of SMEs although not the primary concern. In general, the results broadly correspond with the findings of Ayyagari *et al.* (2010) [26] who showed that Chinese private sector firms tend to rely on informal financing rather than formal alternatives like banks. The respondents, on average, found the fewest difficulties with obtaining private lending (2.11) followed by commercial bank loans (2.32). Venture capital was viewed as the next simplest form of business financing (2.88). The most difficult forms of financing were those that involve capital markets such as the stock (4.05) and bond (4.31) markets. This is likely because the mechanism by which SMEs in China are able to raise money in capital markets remain at an early stage of development. Long (2014), [27] for instance, noted how the Growth Enterprise Market of China (GEMC), designed for emerging entrepreneurial companies, was only established in 2009. Additionally, Chinese stock markets typically function poorly due to corporate opacity, political rent seeking, and weak enforcement of property rights [26]. Bond markets may be even more constrained than equity markets as the institutions associated with the former tend to be monopolized by the state, subject to excessive regulation, and are still at an early stage of development [26, 28, 29].

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5.2 Human resource barriers

Although financial infrastructure and other factors such as market and legal factors are important in driving the adoption of new technologies, human resources are also important. Theoretical frameworks, for instance, have been designed which explore the interplay of technologies with human and other resources for determining whether organizations are able to incorporate IT into their business processes [30]. Research has also shown that clusters of creativity—locations in which there are concentrations of innovative firms—can only emerge if there is a wide range of supportive human resources in the form of expert accountants, lawyers, and other skilled professionals to provide the services necessary to support innovative businesses [31, 32] . Further, the innovation process itself is dependent on human resources and how those human resources are managed, and a failure to harness human resources can impede a firm's innovation capabilities [33].

This study revealed one significant human resource barrier: the lack of promising young scientists (4.72) which was also the factor with the highest RII (0.944) suggesting that respondents to the survey found this to be the most pressing barrier to innovation in Chinese NEV SMEs. A possible reason for this has been highlighted in previous research: the focus of the Chinese education system on passing examinations rather than nurturing the creativity needed for an innovating industry like the NEV industry. Although the education system in China has been substantially revamped over time with a greater emphasis on developing innovation and creativity, many of these changes have only been undertaken in the last 20 years which suggests that any improvements in creativity and innovation may not have had sufficient time to filter through to the workforce [34]. Also, despite these changes, there are concerns that the education system appears to be successful in fostering greater creativity only in younger students while scores on several measures of creativity and innovation decrease in middle school and higher [35].

Another possible reason why Chinese SMEs face a lack of skilled and innovative workers is the presence of a brain drain. Many highly educated and skilled Chinese workers, such as scientists, have become used to foreign cultures after they have lived and studied in other countries and are reluctant to return to China [36]. This is exacerbated by the fact that education has become increasingly internationalized which has allowed Chinese students, especially those from financially able families, to access higher education in other countries [37].

One other significant human resource issue that arose was the lack of employees with foreign language skills and global knowledge (RII = 0.832). A possible reason for this may be that the pace of economic and business growth in China has outstripped the capabilities of the Chinese education system to equip its people with the necessary skills. For instance, while English is a compulsory subject in China, many Chinese students, even at the tertiary level, report difficulties in communicating effectively in English [38].

5.3 Market barriers

Market conditions can also prove to be significant barriers. One example is the lack of physical infrastructure; for instance, poor transport infrastructure has been shown to serve as a strong barrier to the development of textiles and electronics manufacturing industries in Brazil [39]. In the case of NEVs, the most obvious case is the lack of available charging infrastructure (RII = 0.876). This corroborates the findings of Sweda and Klabjan (2011) [40] who found that the lack of a public charging infrastructure is, frequently, one of the most significant barriers to the adoption of NEVs. Needless to say, potential NEV buyers are reluctant to commit to a big-ticket purchase unless they know they have convenient charging access outside the home. While investors are generally reluctant to commit to building a large charging infrastructure without knowing the actual demand for NEVs. These limitations of the available technology are more obvious when considering the fact that the battery range (RII = 0.858), and the lack of core technology and technology development (RII = 0.844), were also found to be significant market barriers to the adoption of NEVs. These factors, when combined with one another, suggest that a single phenomenon of "range anxiety," i.e., consumers' concerns that NEV range not be sufficient for their daily needs, may be responsible for

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reducing the market acceptance of battery-operated NEVs. Dong *et al.* (2014) [41] showed that this may be the case.

Other studies have found evidence that supports the finding that technology limitations have a significant effect on the adoption of NEVs. Egbue and Long (2012) [42] investigated the adoption rate of EVs in the US and found that consumer demand for EVs was inhibited by similar concerns about the technology; most respondents explained that they found the technology unfamiliar and were thus reluctant to commit to EVs. Sierzchula *et al.* (2014) [43] carried out a similar study with consumers in the Netherlands and found that the single most significant factor in determining the adoption of EVs was the availability of charging infrastructure.

5.4 Legal and institutional barriers

Legal and institutional factors were found, in this study, to be the most powerful barriers to the development of NEV SMEs in China. This was somewhat expected at the initiation of the study because the Chinese government maintains a strong hold over the economy and there is evidence that Chinese government policies tend to be relatively uncoordinated at the operational level which makes the regulatory environment more complicated. Additionally, the overall tax policy and burden in China is one of the most onerous in the world [44].

Indeed, various legal and institutional barriers were cited by the respondents as the 2nd to the 5th most significant barriers to NEV SMEs in their growth phase. A lack of, or unclear, regulations in particular, had the highest RII score (0.918) in this category. Gerst and Gao (2015) [45] highlight that the regulatory process for NEVs is particularly complicated. This is because the focus of NEV standards is on interoperability between various technologies which depends heavily on the input of stakeholders from many different industries. Additionally, the market and environment for NEVs is dynamic and constantly changing, not least of which because of the technological barriers that the industry needs to overcome, such as lack of charging infrastructure and limited range of vehicles afforded by current battery technology. The need for interoperability between the various technologies exacerbates some of the tensions that arise; for instance, some manufacturers may experience market pressures to protect intellectual property rights. Yet, the success of the NEV depends on interoperability of the various components that comprise the vehicle, which implies intellectual property sharing.

Another important consideration in China's case is the protection of intellectual property (IP) rights. China has been considered to have a particularly poor record in protecting IP [46]. Nevertheless, Ang *et al.* (2014) [47] examined the various IP laws and the international treaties that China had acceded and found that the IP laws in China exceeded some of the protections offered by the laws in some developed countries. Thus, while proper legislation to protect IP rights exists in China, the enforcement of IP rights is left down to the provinces and may vary widely between them. Ang *et al.* (2014) [47] found that those provinces which better enforcement IP rights also had more R&D investments, generated a larger number of patents, and had greater sales from new products. These results indicate that the enforcement of IP legislation matters just as much as ensuring that IP legislation exists, and that rationalizing the enforcement of IP legislation across China could be of benefit to the Chinese NEV SME sector.

The next most significant legal or institutional barrier to the development of NEV SMEs in China is the presence of government intervention in business. The government plays an extraordinarily large role in the Chinese economy when compared with many other countries. The Chinese government's role in business is exercised through its significant ownership of state-owned enterprises (SOEs) and listed SOEs still dominate the Chinese capital markets. Additionally, the effect of government policies in several industries such as natural resources, civil aviation, real estate, and finance, has been to favor SOEs such that private firms have been crowded out [48].

In the case of the NEV industry, Liu and Kokko (2013) [49] suggested that various branches of the Chinese government are closely involved in managing innovation in the Chinese NEV industry. The government, broadly, plays two roles therein. First, the government prioritizes and allocates investments in the NEV industry to the relevant industry players. Second, it regulates and

coordinates policies to develop the NEV industry in China. Liu and Kokko (2013) [49] explained that the most relevant actors in the NEV industry were car manufacturers who conducted most of the R&D to develop NEV technology in collaboration with research universities and other research institutions. Most of these car companies and research organizations were, in China, public institutions either wholly or partly owned by the government. There is thus the likelihood that, as observed in other sectors, the Chinese government could enact policies that favor state-owned institutions at the expense of private enterprise.

6. Conclusion

6.1 Policy proposals

One of the main hindrances to the growth of Chinese NEV SMEs was access to formal modes of financing such as bond and equity markets. Zhu *et al.* (2012) [44] suggested that one of the issues that limits the access of Chinese SMEs to formal financing was that the SME Promotion Law enacted by the Chinese government did not have sufficient concrete policies that could be enforced operationally. For instance, there were few incentives under the SME Promotion Law to encourage Chinese banks or other providers of capital to properly value the IP generated by innovative firms such as NEV SMEs. Additionally, Wang *et al.* (2015) [50] found that Chinese banks were less comfortable in providing financing to those SMEs who had a strong reliance on R&D expenditure to develop their businesses. As a result, one possible policy measure that the Chinese government could take to encourage NEV SME financing would be to develop operational guidelines vis-à-vis the assessment and valuation of R&D potential of Chinese SMEs, so that they are able to access financing according to their development needs.

Apart from bank financing, bond and equity markets in China also need to be developed so that SMEs can tap alternative formal sources of capital besides bank financing. The Chinese bond market is generally on the right track given that those markets are widening access to foreign buyers so that there is a wider pool of participating investors instead of relying solely on Chinese institutions [51]. Increasing participation in capital markets could be particularly beneficial to innovative companies like NEV SMEs, as international investors may be less likely to exhibit conservative biases against businesses with high R&D requirements. Thus, such a measure could increase the ability of NEV SMEs to raise capital through bond markets.

One other policy measure to increase formal financing options to young and innovative firms would be to develop an equity market that specializes in the trading of SME equity [52]. This was addressed, to some extent, when the Chinese government expanded over-the-counter (OTC) market access to qualified SMEs [53]. Nevertheless, this policy measure had limited impact due to lack of investor interest as a result of the tight regulations on equity markets which thus constrain those equity markets. Therefore, one policy measure that should be considered over the long term would be to liberalize the Chinese economy and relax equity market regulations so that the Chinese equity markets become more attractive to investors and SMEs are better able to tap the equity markets for capital.

Beyond lack of access to formal forms of financing, another significant issue faced by Chinese NEV SMEs is the presence of legal and institutional barriers. One of the most significant legal or institutional barriers arises due to the lack of coordination between the different government agencies governing the NEV industry. Different aspects of NEV policy are addressed by different agencies. The Chinese government should therefore consider consolidating governance over NEV policy into a single "renewable energy department" so that all government policies regarding renewable energy—not just NEVs—can be implemented more effectively. An example that could be pursued further is the development of industrial clusters similar to what has been termed the "Zhejiang model" [54]

Another issue arises due to the fact that the Chinese government, either partially or wholly, holds stakes in a number of significant players in the NEV industry [49]. While this may crowd out private players from the NEV industry, the Chinese government can also take advantage of its

market power to coordinate alliances between companies, research institutes, and universities, so that collaboration within an alliance and competition between alliances can lead to a more robust innovative culture. To address the current lack of demand exhibited by Chinese consumers for NEVs, the government could provide financial incentives to offset some of the cost advantages that traditional vehicles still have over NEVs.

Finally, the single most important barrier to the development of Chinese NEV SMEs has been the lack of skilled scientists. This could be due to the internationalization of higher education where financially able Chinese students have been incentivized to pursue higher education in other countries and then remain in those countries, contributing to their workforce instead of returning to China. Extant policy measures have not been able to completely address the brain drain issue, thus the Chinese government could take further action by negotiating with host countries to address ways in which these individuals could be encouraged to return to China [55]. Additionally, the Chinese government will need to investigate and address some of the push factors, including aspects of cultural, economic, social, and educational policies, which contribute towards the brain drain.

6.2 Limitations and future studies

There are several limitations that need to be considered when interpreting the results of this study. First, survey respondents were captured via a non-probabilistic sampling method. This means that the sample is likely to be biased and the results of this study cannot be generalized to the population of NEV SMEs. Second, the questionnaire used in this study was designed by the researcher but was not trialed before it was implemented on the research sample. Thus, there is a risk that some of the questions used therein may have been misinterpreted by certain respondents, which could have biased some of the results in this study. Future studies should therefore be aimed at overcoming these limitations.

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