

1 Article

2 **Barriers to Constructing New Energy Vehicles** 3 **According to Chinese SMEs**

4 **Qiuyu GaoYan**¹, **Darren McCauley**² and **Natalia Konina**^{3,*}

5 ¹ Graduate student of National Research University and Johns Hopkins University; qgaoyan1@jhu.edu

6 ² University of St.Andrews, Irvine Building, North Street, St Andrews, Fife, KY16 9AL, Scotland, UK;
7 dam7@st-andrews.ac.uk

8 ³ Moscow State University of International Relations (MGIMO University); nkonina777@gmail.com

9 * Correspondence: nkonina777@gmail.com; Tel.: +7(495)234-84-57

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

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

24

25 **1. Introduction**

26 *1.1. Background*

27 New energy vehicles (NEVs) are powered by sustainable sources such as electricity rather than
28 the combustible fuel used in traditional vehicles. NEVs have been recommended as alternatives to
29 traditional vehicles as a result of the increasing acceptance of the role played by human activity in
30 causing climate change. Of the human activities that have a significant impact on the environment,
31 vehicular emissions that arise from the need for transportation are a significant contributor; an
32 estimated 26% of global carbon dioxide (CO₂) emissions are attributed to transportation, including
33 the use of cars, road freight, and aviation [1]. Further, developing countries have witnessed strong
34 growth in domestic demand for motorization in recent years. As a result, the potential increase in the
35 number of private vehicles added to the roads in the world will be likely to overwhelm the benefits
36 to be gained from the use of cleaner fuels. This suggests that a range of measures need to be applied
37 to reduce greenhouse gas (GHG) emissions [2]. NEVs are thus a promising measure to reduce GHGs
38 and have been proposed as a solution to reducing air pollution in countries such as China [3]. NEVs
39 show promise for a country like China for several reasons. First, given enough demand, a move
40 towards partial or fully electric powered vehicles could reduce a country's dependence on
41 petroleum imports. This is particularly significant for a country like China, which is a net crude oil
42 importer. Second, China already suffers significantly from air pollution and the use of NEVs could
43 significantly militate against this [4].

44

45 1.2 Research question and justification

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

60 1.3 Research justification

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

71 1.4 Article structure

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

79 2. Literature Review

80 2.1 The role of energy in the global economy and the imperative for a clean energy transition

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

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

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

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

94 *2.2 Climate change, international policy responses, and new energy sources*

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

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

112 *2.3 Costs and benefits of new energy*

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

119 *2.4 China's energy sector*

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

126 China, however, will need to take into account its resource constraints when steering its new
127 normal framework. The available evidence suggests that China still relies heavily on fossil fuels. As
128 of 2014, renewable energy is only 9% of China's energy mix. Sixty-six percent and twenty percent of
129 the energy used in China is generated by coal and oil respectively, and dependence on imported oil
130 and gas is expected to increase by at least 50% by 2030 [11]. Nevertheless, as part of the new normal
131 developmental framework, China plans to increase its share of non-fossil fuels in the energy mix to
132 20% by 2030 [13]. There is some evidence that China has been moving towards this goal, as its
133 renewable energy share of 9% in 2014 represents a substantial increase compared to the turn of the
134 21st century. Further, in 2014 itself, China installed 70 GW of additional non-coal electrical generation
135 capacity and 53 GW of new energy projects including solar plants, hydroelectric dams, and wind
136 farms [14]. With a new energy based infrastructure, it may be possible to allow for a de-urbanization
137 process to ensue as new energy would allow individuals to move to rural areas and yet have
138 sufficient access to cheap and abundant energy and transportation [15].
139

140 2.5 Changes and innovation in China's energy sector in the 21st Century

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

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

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

165 3. Methodology

166 3.1 Data collection

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

172 3.2 Data analysis

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

$$178 \text{ RII} = \frac{\sum \omega}{A \times N}$$

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

181 3.3 Validity, reliability, and limitations

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

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

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

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

203 4. Results

204 4.1 Respondents' Characteristics

205 A total of 120 initial responses were obtained from NEV SME entrepreneurs within two months
206 of initial solicitation. Twenty of the responses were removed from the sample due to incomplete or
207 invalid answer sets. Thus, data from a total of 100 respondents are available for analysis. Most of the
208 entrepreneurs who responded to the study were relatively young: 23% of respondents were 20–30
209 years old; and 45% were 31–40. Befitting a technologically intense industry, 93% of surveyed
210 entrepreneurs are educated to degree level or higher with a full 33% of the sample consisting of
211 entrepreneurs with postgraduate (either Masters or PhD) degrees. Additionally, the majority of the
212 employees in the companies represented by the surveyed entrepreneurs tended to be educated to at
213 least degree level: 58% of respondents reported that at least 70% of their employees had
214 undergraduate degrees or higher. The respondents to the survey were also overwhelmingly male
215 (84%). Further, 39% were unmarried, 37% married without children, and 24% married with children.
216 All of the entrepreneurs were already experienced with business and had run businesses in other
217 sectors prior to being involved in the NEV industry. The most common industries previously
218 experienced by the respondents were conventional energy (25%), real estate (23%), manufacturing
219 (20%), and finance and consulting (17%). Interestingly, only 5% of respondents had previous
220 experience with businesses in the automobile sector.

221 The companies run by the respondents were generally younger companies. Twenty-seven
222 percent of respondents reported that their companies were between 1 to 3 years old, while 43%
223 reported that they had been running the companies for between 3 to 5 years. The companies were
224 generally small, with 12% of respondents reporting that they had fewer than 100 employees, 20%
225 from 100 to 200 employees, and 28% of respondents from 200 to 300 employees. Nevertheless, the
226 companies tended to have a significant amount of assets with 37% of respondents reporting that
227 their business had assets of between 10 million to 25 million RMB; 28% of respondents reported
228 assets of between 25 million and 50 million RMB. Start-up costs were also generally quite significant:
229 31% of entrepreneurs reported that it took between 1 million to 2 million RMB; while 54% provided
230 figures indicating that the seed capital was 2 million RMB or more. This seed capital was mostly
231 provided by commercial bank loans (47%) although self-financing (23%) and government bank loans
232 (15%) were also significant sources of start-up capital. The most common reason given by
233 respondents for starting their business in the NEV industry was "governmental incentives and
234 subsidies" (45%), followed by "I have a patented technology and I want to commercialize it" (30%).
235 "NEV is new to me but with a 'NEV' label, I could upgrade my original business model and achieve

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

238 4.2 Analysis of barriers

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

245 **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 |

| | | | | |
|---|-------|-------|-------|----|
| 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 |

246 5. Discussion

247 5.1 Financial barriers

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

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

273 5.2 Human resource barriers

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

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

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

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

309 5.3 Market barriers

310 Market conditions can also prove to be significant barriers. One example is the lack of physical
311 infrastructure; for instance, poor transport infrastructure has been shown to serve as a strong barrier
312 to the development of textiles and electronics manufacturing industries in Brazil [39]. In the case of
313 NEVs, the most obvious case is the lack of available charging infrastructure (RII = 0.876). This
314 corroborates the findings of Sweda and Klabjan (2011) [40] who found that the lack of a public
315 charging infrastructure is, frequently, one of the most significant barriers to the adoption of NEVs.
316 Needless to say, potential NEV buyers are reluctant to commit to a big-ticket purchase unless they
317 know they have convenient charging access outside the home. While investors are generally
318 reluctant to commit to building a large charging infrastructure without knowing the actual demand
319 for NEVs. These limitations of the available technology are more obvious when considering the fact
320 that the battery range (RII = 0.858), and the lack of core technology and technology development (RII
321 = 0.844), were also found to be significant market barriers to the adoption of NEVs. These factors,
322 when combined with one another, suggest that a single phenomenon of "range anxiety," i.e.,
323 consumers' concerns that NEV range not be sufficient for their daily needs, may be responsible for

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

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

333 5.4 Legal and institutional barriers

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

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

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

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

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

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

382 6. Conclusion

383 6.1 Policy proposals

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

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

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

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

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

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

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

439 6.2 Limitations and future studies

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

448 **Acknowledgments:** This piece of work is based on my master dissertation when I was pursuing a double
 449 master program in sustainable energy between University of St. Andrews and MGIMO.

450 I would like to thank all faculty members from department of sustainable development University of St.
 451 Andrews; and MIEP MGIMO university, for helping me with my research. Special thanks to my supervisor,
 452 Professor Natalia Konina, for her encouragement and guidance. I also want to thank Dr. Darren McCauley for
 453 his review.

454 **Author Contributions:** First Author: Qiuyu GaoYan; research design, data collection, writing and revising.

455 Corresponding Author: Natalia Konina, Supervision, revision suggestions and cover letter preparation.

456 Second Author; Darren McCauley, Review and revision suggestions.

457 **Conflicts of Interest:** All the authors have no conflicts of interest.

458 References

- 459 1. Chapman, L. Transport and climate change: A review. *J. Transp. Geogr.* 2007, 15, 354-367.
- 460 2. Gong, H.; Wang, M. Q.; Wang, H. New energy vehicles in China: Policies, demonstration, and progress.
 461 *Mitigating and Adaptation Strategies for Global Change* 2013, 18, 207-228.
- 462 3. Kimble, C.; Wang, H. China's new energy vehicles: Value and innovation. *Journal of Business Strategy*
 463 2013, 34, 13-20.
- 464 4. Green Alliance Trust. (2015). *Paris 2015: Getting a global deal on climate change*. [online] Accessed July 4th
 465 2016. Available at: <http://www.green-alliance.org.uk/paris2015.php>
- 466 5. Green, F.; Stern, N. (2015). *China's 'new normal' structural change, better growth and peak emissions*. London,
 467 UK: Grantham Research Institute.
- 468 6. Yuan, J.; Xu, Y.; Zhang, X.; Hu, Z. China's 2020 clean energy target: Consistency, pathways and policy
 469 implications. *Energy Policy* 2014, 65, 692-700.
- 470 7. Shell International BV. (2011). *Shell energy scenarios to 2050: Signals & signposts*. [online] Updated February
 471 14th 2011. Accessed July 3rd 2016. Available at: [http://www.shell.com/media/news-and-media-releases/
 472 2011/scenarios-signals-signposts.html](http://www.shell.com/media/news-and-media-releases/2011/scenarios-signals-signposts.html)

- 473 8. Lockström, M.; Callarman, T.; Lei, L. The electric vehicle industry in China and India: The role of
474 governments for industry development. In *Industrial dynamics in China and India*; Ohara, M., Vijayabaskar,
475 M., Lin, H., Eds.; Palgrave Macmillan: Basingstoke, UK, 2011; pp. 203-225.
- 476 9. Tan, Q.; Wang, M.; Deng, Y.; Yang, H.; Rao, R.; Zhang, X. The cultivation of electric vehicles market in
477 China: Dilemma and solution. *Sustainability* **2014**, *6*, 5493-5511.
- 478 10. Xie, X.M.; Zeng, S.X.; Tam, C.M. Overcoming barriers to innovation in SMEs in China: A perspective
479 based cooperation network. *Innovation: Management, Policy & Practice* **2010**, *12*, 298-310.
- 480 11. Zeng, S.X.; Tam, C.M.; Tam, V.W.Y.; Deng, Z.M. Towards implementation of ISO 14001 environmental
481 management systems in selected industries in China. *Journal of Cleaner Production* **2005**, *13*, 645-656.
- 482 12. Cronbach, L.J. Coefficient alpha and the internal structure of tests. *Psychometrika* **1951**, *16*, 297-334.
- 483 13. Aghion, P.; Fally, T.; Scarpetta, S. Credit constraints as a barrier to the entry and post-entry growth of
484 firms. *Economic Policy* **2007**, *22*, 732-779.
- 485 14. Gregory, B.T.; Rutherford, M.W.; Oswald, S.; Gardiner, L. An empirical investigation of the growth cycle
486 theory of small business financing. *Journal of Small Business Management* **2005**, *43*, 382-392.
- 487 15. Ayyagari, M.; Demirgüç-Kunt, A.; Maksimovic, V. Formal versus informal finance: Evidence from China.
488 *Review of Financial Studies* **2001**, *23*, 3048-3097.
- 489 16. Long, H. Exploring the principal factors influencing IPOs in the emerging growth enterprise market of
490 China. *International Journal of Trade, Economics and Finance* **2014**, *5*, 77-81.
- 491 17. Pang, W.; Plucker, J.A. Recent transformations in China's economic, social, and education policies for
492 promoting innovation and creativity. *Journal of Creative Behavior* **2012**, *46*, 247-273.
- 493 18. Fu, M. A cultural analysis of China's scientific brain drain: The case of Chinese immigrant scientists in
494 Canadian academia. *Journal of International Migration and Integration* **2014**, *15*, 197-215.
- 495 19. Mok, K.H.; Han, X. From 'brain drain' to 'brain bridging': Transnational higher education development
496 and graduate employment in China. *Journal of Higher Education Policy and Management* **2016**, *38*, 369-389.
- 497 20. Peng, S. Analysis of perceived difficulty rank of English skills of college students in China. *Studies in*
498 *Literature and Language* **2014**, *8*, 15-21.
- 499 21. Sweda, T.; Klabjan, D. An agent-based decision support system for electric vehicle charging infrastructure
500 deployment. In *7th IEE Vehicle Power and Propulsion Conference*, Chicago, 2011.
- 501 22. Dong, J.; Liu, C.; Lin, Z. Charging infrastructure planning for promoting battery electric vehicles: An
502 activity-based approach using multiday travel data. *Transportation Research Part C: Emerging Technologies*
503 **2014**, *38*, 44-55.
- 504 23. Egbue, O.; Long, S. Barriers to widespread adoption of electric vehicles: An analysis of consumer
505 attitudes and preferences. *Energy Policy* **2012**, *48*, 717-729.
- 506 24. Sierzchula, W.; Bakker, S.; Maat, K.; van Wee, B. The influence of financial incentives and other
507 socio-economic factors on electric vehicle adoption. *Energy Policy* **2014**, *68*, 183-194
- 508 25. Zhu, Y.; Wittmann, X.; Peng, M.W. Institution-based barriers to innovation in SMEs in China. *Asia-Pacific*
509 *Journal of Management Research and Innovation* **2012**, *29*, 1131-1142.
- 510 26. Gerst, M.; Gao, X. IP and electric vehicles standards: Local policies vs. global standards? Standardization
511 management in a multi-stakeholder environment in China. In *Effective standardization management in*
512 *corporate settings*, Jacobs, K. Ed.; IGI Global, 2015.
- 513 27. Maskus, K., Dougherty, S., Mertha, A. Intellectual property rights and economic development in China.
514 In *Intellectual property and development: Lessons from recent economic research*, Fink, C., Maskus, K., Eds.,
515 Oxford University Press: Oxford, UK, 2005, pp. 295-311.
- 516 28. Ang, J. S.; Cheng, Y.; Wu, C. Does enforcement of intellectual property rights matter in China? Evidence
517 from financing and investment choices in the high-tech industry. *Review of Economics and Statistics* **2014**,
518 *96*, 332-348.
- 519 29. Chen, S.; Sun, Z.; Tang, D.; Wu, D. Government intervention and investment efficiency: Evidence from
520 China. *Journal of Corporate Finance* **2011**, *17*, 259-271.
- 521 30. Liu, Y.; Kokko, A. Who does what in China's new energy vehicle industry? *Energy Policy*, **2013**, *57*, 21-29.
- 522 31. Wang, J.; Robson, P.; Freel, M. The financing of small firms in Beijing, China: Exploring the extent of
523 credit constraints. *Journal of Small Business and Enterprise Development* **2015**, *22*, 397-416.
- 524 32. Reuters. (2013). *China widens access to over-the-counter exchanges*. Financial Times [online] Updated
525 December 14th 2013. Accessed 7th June 2016. Available at: <http://www.ft.com/intl/cms/s/0/e772da90-64b9-11e3-a821-00144feabdc0.html#axzz48h0vnT1t>
- 526

- 527 33. Bellandi, M.; Lombardi, S. Specialized markets and Chinese industrial clusters: The experience of
528 Zhejiang Province. *China Economic Review* **2012**, *23*, 626-638.
- 529 34. Roudgar, I.; Richards, C. The policy challenge of the global brain drain: Addressing the dilemmas of
530 contributing push-pull factors. *International Journal of Public Policy* **2015**, *11*, 73-85.
- 531 35. Buijs, B. *China and the future of new energy technologies: Trends in global competition and innovation*.
532 Clingendael International Energy Programme, Clingendael Energy Paper, March 2012.
- 533 36. Cetkovic, S.; Buzogany, A. *The 2020 strategy experience: Lessons for regional cooperation*. Working paper
534 presented at DIW Berlin, Berlin, 17 June 2015.
- 535 37. Chassin, Y.; Tremblay, G. *Practical guide to the economics of climate change: The Paris Conference and its*
536 *aftermath*. Montreal Economic Institute Research Papers, November 2015. Accessed July 3, 2016. Available
537 at: http://www.iedm.org/files/cahier0415_en.pdf
- 538 38. Earth Policy Institute. (2015). *The Great Transition: Shifting from fossil fuel to solar and wind energy*. Newark,
539 NJ: Rutgers University Press.
- 540 39. Federal Ministry of Economics and Technology. (2014). *Germany's new energy policy: Heading towards 2050*
541 *with secure, affordable and environmentally sound energy*. [online] Updated April 2012. Accessed July 5, 2016.
542 Available at: <http://www.bmwi.de/English/Redaktion/Pdf/germanys-new-energy-policy>
- 543 40. **Gallagher, L.** (2015). *Political economy of the Paris climate agreement*. [online] Accessed July 4, 2016.
544 Available at: http://act2015.org/ACT_2015_FINAL_Political_Framing.pdf
- 545 41. Heale, R.; Twycross, R. Validity and reliability in quantitative studies. *Evidence-Based Nursing* **2015**, *18*,
546 66-67.
- 547 42. International Renewable Energy Agency. *Rethinking energy*. IRENA Publications: Abu Dhabi, UAE,
548 2014.
- 549 43. **Karplus, V. J.** (2007). Innovation in China's energy sector. Working Paper #61, Program on Energy and
550 Sustainable Development, Stanford University.
- 551 44. Lv, P.; Spigarelli, F. The integration of Chinese and European renewable energy markets: The role of
552 Chinese foreign direct investment. *Energy Policy* **2015**, *81*, 14-26.
- 553 45. Ma, D. (2015). Rebalancing China's energy strategy. Paulson Papers on Energy and Environment. January
554 2015.
- 555 46. McNabb, D.E. *Research methods for political science: Quantitative and qualitative approaches*. 2nd ed. New York,
556 NY: Routledge, 2015.
- 557 47. Shi, D. Understanding China's energy strategy and its sustained economic growth: Present and future.
558 *China Finance and Economic Review*, **2015**, *3*, 1-8.
- 559 48. Timmons, D.; Harris, J. M.; Roach, B. *The economics of renewable energy*. Tufts University: Medford, MA,
560 2014.
- 561 49. /World Economic Forum. (2013a). *Energy vision 2013: Energy transitions*. Cologne: HIS CERA.
- 562 50. /World Economic Forum. (2013b). *The Global energy architecture performance index report 2014*. Geneva,
563 Switzerland: World Economic Forum.
- 564 51. /Wright, L.; Fulton, L. Climate change mitigation and transport in developing nations. *Transport Reviews*
565 **2005**, *25*, 691-717.
- 566 52. Zhang, P., Yang, Y., Shi, J., Zheng, Y. Wang, L.; Li, X. Opportunities and challenges for renewable energy
567 policy in China. *Renewable and Sustainable Energy Reviews* **2009**, *13*, 439-449.
- 568 53. Zhao, J. (2001). Reform of China's energy institutions and policies: Historical evolution and current
569 challenges. BCSIA Discussion Paper 2001-20, Energy Technology Innovation Project, Kennedy School of
570 Government, Harvard University.
- 571 54. Zheng, Z. (2014). Status and prospects of the development of Chinese SMEs. Paper presented at the
572 Global Ethics Forum 2014, Bangalore, India, January 3-5, 2014.