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Chapter 4

Electric Vehicle Promotion Policy in Taiwan

Li-Min Cheng

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Abstract

The developmental patterns of automotive industries in developing countries differ from those in developed countries. Nations should actively and effectively develop an electric vehicle (EV) industry to reduce carbon dioxide emissions and energy consumption, especially during this period of increasing fuel prices and emphasis on saving energy and reducing carbon emissions. From interdisciplinary perspectives, this study analyzed the promotion methods of the EV industry in Taiwan. In addition, we suggest that the Taiwan government should use its advantages in Central Taiwan to assemble mature suppliers of precision machinery in this area to facilitate long-term research and development for the EV industry. This study provides an empirical experience for emerging cities in developing countries regarding the development of the EV industry and is an appropriate reference for the creation of EV industry clusters.

Keywords: EV, electric vehicle, EV industry, carbon-reducing policy, green transportation

1. Introduction

Because China's economy and other developing countries are experiencing rapid development, the automotive industry has become one of the most quickly developing industries and is a major source of air pollution. To improve air quality, numerous governments of developed countries have established relevant laws and policies [1] to decrease the number of active old vehicles and actively develop the low-pollution or low-emission automotive industry through subsidization. McElroy [2] argued that subsidies are a constructive option for the development of relevant industries and for reducing our dependence on traditional energy sources.

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Traditional studies regarding gaseous pollutants from automobile emissions have focused on microcosmic or technical discussions, such as the improvement of internal combustion engine efficiency (e.g., see [3]). Macroscopic perspectives on industrial development are scant, as are comprehensive studies on the EV industry. However, because they are constrained by financial and market factors, developing countries should identify a novel pattern for developing automotive industries that differs from those of developed countries and should actively and efficiently develop EV industries to reduce carbon dioxide emissions and energy consumption. These are particularly pressing issues because of increasing fuel prices and the current emphasis on saving energy and reducing carbon emissions.

Taiwan government eagerly promotes the low-carbon policy in recent years. Since being selected by the Environmental Protection Administration (Executive Yuan) of Taiwan as a low-carbon model city, the Taichung city government issued the "Regulations of task force for the promotion of low-carbon city, Taichung city government" on October 24, 2011. This study uses that experience to explain the EV promotion policy in Taiwan.

To foster and initiate low-carbon industries, the city government founded the "economic development and agriculture team" within the promotion task force to evaluate related carbon-reducing policies and plans for the development of Taichung industries. The results of these measures led to Taichung's emergence as the best city in Taiwan. Regarding the experience pattern or model of Taichung's development, this study examined Taichung's efforts in assisting the EV industry and in transforming local industries into low-carbon industries from interdisciplinary perspectives. In addition, this study also evaluated and analyzed the feasibility of future plans. The developmental patterns that we examined can be used as a reference for industrial planning by similar cities in developing countries and can contribute to creating a low-carbon and green industry environment.

2. Literature review

Regarding the policies adopted by governments for industrial development, Rothwell and Zegveld [4] suggested that innovation in emerging technologies and industries can facilitate national economic growth. From the perspective of industry, policies are a practical means for governments to become involved in the technological development system. Governmental innovation policies should include technological and industrial policies, and, according to their influence or effects on technological activities, policies are categorized as bellow:

- Supply policies: manpower, finance, public services, and technical support are the determinants of a government's direct involvement in technology supply.
- Demand policies: governments establish market-centered policies that provide demands for technology and, thereby, affect technology development, such as purchases and contracts regarding technological products by central or local governments.
- Environmental policies: governments draw up related laws, including industry districts or parks, taxes, and patents, that regulate the economy and indirectly affect the technology

development environment. To achieve their various goals, governments should adopt different methods and means to execute their policies.

Therefore, governments should implement the establishment of EV industry clusters using the above policy facets. Porter [5] provides the following definition of the "clustering effect": If the upstream and downstream of a specific industry tend to correlate in terms of regions, they will progressively evolve into a structure of economic benefit that elevates mutual efficiency and professionalism. Consequently, a cluster of enterprises dramatically enhances the overall competiveness of industries through self-development and flexible adjustment using internal forces. Kotval and Mullin [6] indicated that clusters have become planning behaviors conducted and adopted by nations, governments, and local authorities. Many nations include industry clusters as a national policy to enhance their international competitiveness. For example, the U.K. promotes the information and technology industry in the Thames Valley, develops engineering-related clusters in the Northeast, promotes aviation industry clusters in Bristol, and develops biochemical technology near Cambridge [7]. In addition, numerous other areas have had similar success in the establishment of clusters [8, 9], such as the most acclaimed example of a successful cluster: Silicon Valley in California.

Furthermore, in terms of law and technology law, legislation regarding energy laws and regulations has gained increasing attention from developed countries. Specifically, during the energy crisis in the 1970s, governments in developed countries exercised peak control of energy-based commercial activities [10]. Elliott [11] cited the UK as an example, which amended its Building Regulations in 2004 because of carbon trading concepts. Bührke [12] approved of the German federal government's action of reducing 40% of Germany's carbon dioxide emissions by enacting the Renewable Energy Sources Act (EEG). In 1992, the United States passed the Energy Policy Act (EP Act 92), which has played a critical role in the restructuring of the power and electricity industry. The act was amended in 2005 (EP Act 2005) to reinforce the influence of the Federal Energy Regulatory Commission (FERC) in the power and electricity industry. The American Recovery and Reinvestment Act (ARRA) of 2009 perpetuated the strength of the federal government in energy and power policies and regulations. Therefore, powerful interventions from the government and legislative support are necessary for energy and power policies and regulations [10].

Preparations for developing EVs, such as regulatory administration that can limit traditional vehicles, or supply administration that rewards and subsidizes the EV industry, cannot be ignored. Relevant departments must conduct a regulatory impact analysis (RIA) [13–15] to judiciously plan the comprehensiveness of legislation for regulatory and supply administration. Similar to business impact analysis (BIA), RIA requires that administrative sections or agencies clearly specify regulative backgrounds (e.g., the overall economic environment and market structure of industries), controversies regarding acts and laws caused by social demands and conflicts relevant to existing laws, expected efficacy or function of acts, and the relationships among issues during the legislative operations process. These sections and agencies should also propose and draft plausible measures (including concrete regulative contents for all possible legal and non-legal alternatives, and clarification of their necessity) and analyze and evaluate the related efficiency and costs influenced by people, enterprises,

and governments for the implementation of these measures, which provides a reference standard for governmental legislation. Staroňová et al. [16] proposed that the quality of legislative drafts could be enhanced using RIA, and Hertin et al. [17] maintained that RIA ensures appropriate policy deliberations and provides for effective problem-solving within policy design.

In addition, because the regulatory administration that limits traditional vehicles is a violation of people's freedom and rights, according to Articles 102 and 164 of the Administrative Procedure Act, Taiwan's government is responsible for holding hearings in which public opinions and feedback are consulted. Noland [18] argued that proper assessment procedures are a means to keep the rhetoric surrounding decision-making honest, both by providing the best information and analysis to the public and by establishing a framework for examining this information.

Based on evaluation information regarding industrial environments and external markets, this study provides a guide for market strategy positioning and an analysis of industrial innovation requirements and industrial portfolios. Furthermore, we provide advices regarding the developmental strategy of the EV industry in Taichung, Taiwan, and these suggestions can be expanded as reference standards for industrial development in similar cities in developing countries.

3. The practical EV experience in Taiwan

3.1. The current status and operations of EV in Taichung, Taiwan

Being the second large city in Taiwan, Taichung city government takes lots of measures to promote innovations. In recent years, numerous innovations and advancements, such as the development of broadband infrastructure and the construction of an intelligent city, were implemented by the Taichung city government. As a first-time applicant, Taichung was named one of the top seven intelligent cities in the World in 2012 by the Intelligent Community Forum (ICF). Furthermore, Taichung city was nominated Smarter City in "Smarter Cities Challenge" plan by IBM in 2015, the only city in Taiwan. The Taichung city government is enthusiastically constructing a "carbon free, trouble free" world-class city, and establishes low-carbon city promotion task force to implement the related policies, especially the EV policy.

The most notable measure on the part of the Taichung city government was the distribution of 64 intelligent EVs to government departments for official use on February 7, 2012. The government also created 64 charging stations, demonstrating Taichung's determination to create a leading low-carbon model city in Taiwan. Furthermore, to promote Taichung as an EV model city, the mayor proclaimed an exemption for vehicle license taxes, fuel taxes, parking fees, and charging fees for EVs. One week later, it was announced that free shuttle EVs would be available to citizens and officials for use between three major civic centers in Taichung.

Regarding administrative work, the Environmental Protection Bureau of Taichung city government has enacted the "regulations for applications and verifications of air pollution prevention

funds for establishing air quality purification areas and low-carbon city facilities." These regulations provide subsidies for Taichung city government offices and public schools to establish EV charging stations, with an amount of NTD$ 100–200 thousand provided based on the construction process for each station. Therefore, Taichung has made a firm step in better utilizing government vehicles and public services for citizens. Research for relevant industries indicates that the 2009 greenhouse gas emissions caused by fuel combustion in Taichung comprised 4285.8 thousand metric tons, which was 42.9% of the total greenhouse gas emissions. Compared with the emissions from 2000, we determined that the increased rate of greenhouse gas emissions during these 10 years was 31.05%. The government of Taichung plans to achieve its mid-stage goal for energy and resource reduction before 2020 by actively developing the EV industry and relevant complementary measures. The goal of the Taichung city government is to reduce the consumption of diesel fuel and gasoline by 42.09 and 21.99%, respectively, with a total greenhouse gas reduction rate of 28.98%.

3.2. Prospects of the EV Industry in Taiwan

According to an evaluation report published by the Intergovernmental Panel on Climate Change (IPCC), current global warming, which is chiefly caused by human activities, manifests a clear tendency that will result in a greenhouse effect that induces famine, water shortages, and the extinction of one third of existing species [19]. After the Kyoto Protocol took effect in 2005, the signatories created various compulsory or flexible regulatory mechanisms, such as carbon levies or taxes and carbon trading, to achieve the goal of reducing greenhouse gas emissions. Taiwan is not a member of the United Nations and did not sign the Kyoto Protocol. However, Taiwan cannot ignore the responsibility of being a global citizen. Taiwan should comply with relevant environmental protection conventions and regulations because it adopts trading and commercial relationships with numerous countries and relevant industries in the country experience the pressure of globalization and internationalization.

The central government of Taiwan has responded to this trend, and the Intelligent Electric Vehicle Promotion Office, Industrial Development Bureau, Ministry of Economic Affairs, was officially established in 2010. In addition, the Executive Yuan has listed intelligent EVs as a priority among the four major emerging intelligent industries. The Ministry of Economic Affairs created and drafted the "Intelligent Electric Vehicle Development Strategies and Promotion Plan" and five explicit major promotional strategies to popularize the use of EVs by actively constructing environmental facilities and providing tax concessions. By assisting industrial development, the government intends to make the development of EVs in Taiwan a global model and to fulfill the policy goal of creating a low-carbon Taiwan. It is expected that by 2016, over 60 thousand intelligent EVs will have been produced, an output value for manufacturing greater than NTD$ 120 billion and an output value for the service industry of NTD$ 31.2 billion achieved, and more than 24,000 jobs created. In the future, the Ministry of Economic Affairs will dedicate itself to developing a prototype for the EV industry chain by proposing solutions for green transportation, ranging from upstream batteries, charging stations, mid-stream motors, controllers and other components, and downstream vehicle manufacturing.

Boyer and Verma [20] explained that, to improve capacity management abilities, appropriate measures should be devised. In addition, Greenhalgh and Rogers [21] suggested that governments should establish innovative policies, create parameters for intellectual property right systems, and provide research funds to industries. Therefore, the prospective development of Taichung should refer to the mentioned suggestions. Furthermore, Taichung as a direct-controlled municipality can induce inter-regional momentum for nearby cities and counties, accommodating long-term developmental strategies for governance mechanisms in administrative regions.

Regarding geographic location and environment, the complete transportation network of Taichung includes Taichung Harbor, the airport, highways, and railways. If geographic and transportation resources can be properly managed and adopted, these can catalyze the growth of industries in Central Taiwan. The Taichung city government manifested its determination to "promote green transportation" and to "build a convenient and friendly green transportation environment" in its 2011–2014 medium-term policy and project outline and environmental health policy planning goals. To achieve this goal, Taiwan government must utilize its advantageous location in Central Taiwan. The central region includes developed machinery industries with complete satellite factories. Consequently, the Taiwan government should assemble mature precision machinery suppliers in the central area to develop and foster the EV industry, and connect with other suppliers in nearby cities and counties such as Changhua and Miaoli to create a green-transportation environment.

3.3. Technology developments and limitations of the EV industry in Taiwan

Presently, power is not the only focus of EV development in advanced countries. The computer technology and added intelligent functions have also been integrated. The major directions for EV research and development comprise two areas: intelligent safety systems and EV systems. Intelligent safety systems, which allow drivers to control their vehicle with greater ease, include forward collision prevention for urban areas, intelligent integrated displays of screen information; driver status monitoring that is integrated with vehicle signals, complete moving object detection, intelligent parking guidance systems, and integrated torque sensors. EV systems include advanced and chic technologies such as full vehicle control systems, constant electricity leakage detection, adjustable air conditioning (including heating and cooling), vacuum brake booster systems, and rapid and flexible battery installation structures. Rechargeable batteries available in the EV market consist of four major types, Ni-MH, LiMn, LiFePO4, and LiNiCoMn, each with respective pros and cons. Scholars believe that LFP batteries, which are extremely safe and long-lasting, will be the choice of the next generation and will be directly used in EVs.

However, EVs' limited power causes doubt for customers when purchasing, for which the wide-spread construction of charging stations and pillars are solutions that can be implemented currently. During the 64th Frankfurt Motor Show in 2011, TÜV Rheinland, Germany, published its "Global Electric Vehicle Survey." The survey was an extensive international research on 12 major global vehicle markets, including China, Denmark, Germany, France, India, Israel, Italy, Japan, Portugal, Spain, the United Kingdom, and the United States. This

study indicated that most respondents regarded pricing as the primary intervening factor when considering EV purchase; limited mileage or range was the second factor [22].

Responding to this "range anxiety," some of the battery replacement technologies on the market, such as that developed by Better Place, enable the replacement of the original rental battery in an EV with a fully charged one within 1 minute using robotic arms installed in replacement stations [23]. If related technologies can be introduced, the Taichung City Precision Machinery Innovation Technology Park, with its accomplished experience and ability in precision machinery, could realize this possibility. However, technologies for wireless charging remain in the preliminary stages. The proposals for these technologies, such as those regarding the Alliance for Wireless Power and Plugless Power [24, 25], are too immature to be adopted in practice.

To accommodate this trend, Taiwan must conduct research on pertinent technologies and devise appropriate plans. The core cluster of precision machinery industries in central Taiwan, which has the highest production or output value and density per unit area worldwide, is located in Taichung. The central region's efforts in precision machinery have made Taiwan the fourth leading country in machine tool manufacturing and the third leading country in exports. Machine tool manufacturers in Taichung have developed hard power for manufacturing complete sets or machines and critical parts, especially in areas such as the critical technologies of machine tools for 3C and automobile parts processing, virtual machine tools, computer visual recognition and positioning, and intelligent automation and robotics. In the future, a characteristic EV industrial environment can be established if the industry can further understand trends and accommodate user demands, and employ soft power technologies, such as digital analysis and design, mechatronic integration, and value-added software, from a perspective of system integration.

According to data and statistics from the Taiwan Industrial Technology Research Institute, a total of 37 factories or vendors are currently developing 9 major EV battery related products, including cathode materials, anode materials, battery modules, electrolytes, battery systems, separators, battery cells, current converter modules, and management systems. In addition, because it became a directly-controlled municipality in 2010 and the leading region in Central Taiwan, Taichung should be able to effectively cooperate with nearby cities and counties to expand and develop the EV industry market. As an example, nearby Changhua County possesses more than 200 factories or vendors that produce automobile parts and comprise 10% of related factories in Taiwan. Sales in the tire and rubber industry in Changhua County constitute 50–60% of all automobile part sales in Taiwan (ARTC, 2012). As the largest cluster of automobile parts industries in Taiwan, more than half of all automobile parts are manufactured in Changhua County, including lighting systems, automotive multimedia audio-visual systems, mirrors, tires, seat belts, lamp rims, straps and belts, HID lamps, rear-view mirrors, gear sticks or knobs, windshield wipers, steering wheel covers, headlight rims, car cigarette lighters, carbon removers and cleaners, and decorative accessories. The largest automaker in Taiwan, Yulon Motor, is located in Miaoli County, which is north of Taichung. In 2009, Yulon Motors combined "luxury" and "genius" to create its private brand, "Luxgen," which is the primary EV brand used by the Taichung city government. The Luxgen brand EV run a good start in test project, and it will be the first choice of

Taiwan government use that will be benefit to cultivate the consumer habit of EV. In conclusion, Taichung possesses sufficient qualifications, including advantages in population, geographic location, and industrial environment, for developing the EV industry.

4. Findings and suggestions

4.1. Findings

Mainstream choices in the current automobile market are European, American, and Japanese vehicles, and developing countries should determine custom paths that differ from those of developed countries when developing automobile industries. In light of increasing fuel prices and the emphasis on saving energy and reducing carbon emissions, this study suggests that developing countries, because they are newcomers to the automobile industry, resist endeavors to improve the performance of traditional internal combustion engines. Rather, they should actively and effectively advocate the development of the EV industry, which not only represents a transformation in the form of automobile power, but can be revolutionary in people's lives and in governments' efforts regarding the blue ocean strategy.

Taiwan has actively promoted the EV industry, according to the proclamation of the intelligent EV scheme issued by the Department of Industrial Technology of the Ministry of Economic Affairs: "This scheme aims to promote the technology development of critical parts and the enhancement of product performance for intelligent EVs, and also to refine the verification standard of critical parts for intelligent EVs and the establishment foundation for vehicle verification platforms. The results will be adopted as industry regulations for technological development of intelligent EVs and critical parts to lead the world in the establishment and development of EV specifications".

Although Taichung was selected by Taiwan government as a low-carbon model city and has made a preliminary step in developing EV operations, this study believes that Taichung should dedicate itself to the development of the EV industry as soon as possible, using its advantages in industrial environments and immense EV-related industry chain. The enhancement of the technological competence of existing traditional automobile manufacturers is not the only possible gain. With the assistance of digital technologies, Taiwan could achieve advanced levels similar to those worldwide, and job opportunities for employees with digital talents can be created. Consequently, we offer the following suggestions:

4.2. Suggestions

4.2.1. Administration

- For proper planning of policies, dedicated units should reinforce contact between government organizations:

The dedicated unit of the "low-carbon office" is a high-level unit that makes comprehensive plans and supervises the promotion of green policies in related government organizations in

Taichung. However, dedicated units should appropriately and promptly consider and detect shifts of external industrial environments and technology and strengthen horizontal contact and communication between governmental organizations to assist the transformation of local industries (e.g., when adopting the goal of building a low-carbon city, the office should promote EVs while simultaneously considering the concept of intelligent houses and consulting the Urban Development Bureau, Economic Development Bureau, Construction Bureau, Transportation Bureau, and Environmental Protection Bureau). Because it is restricted by various organizational positions and capacities, administration is frequently censured for its inability to offer macroscopic opinions with foresight even if each organization has its own responsibilities. Therefore, appropriate policy planning and execution can be achieved by following the example of the operation of the interagency climate change adaptation task force of the U.S. Federal Government.

- Government organizations should actively cooperate with the plans developed by dedicated organization for the superior execution of policies:

The current execution regarding EV promotion policies is under the direction of the Environmental Protection Bureau. However, as mentioned, the bureau is deficient in both its ideas and other duties. To solve this problem, policy instruction and appropriate levels of novel technical ideas can be provided by the low-carbon office. In addition, executive units should deliberate on methods for accommodating policies (e.g., regulation amendments, budgeting, and environment construction) and cultivate core abilities to respond to, and fulfill, policy demands.

- Appropriate reward and incentive measures should be provided to stimulate consumer demand:

The four exemptions of vehicle license taxes, fuel taxes, parking fees, and charging fees that are offered by the Taichung city government, despite their benefits, fail to generate sufficient inducement for consumers to purchase EVs. We believe that consumer demands could be stimulated and the sales and supply of EVs could be enhanced if superior subsidies for vehicle purchasing are provided. An additional means of generating incentive is to follow the example of the policy subsidy of USD$43 million provided for battery manufacturers by the U.S. Department of Energy in August 2012. These subsidies will initiate the advanced emergence of the golden cross for supply and demand curves.

4.2.2. Industries

Following decades of development and transformation, the precision machinery industry has evolved into an essential target for development in Central Taiwan, and the Taichung Precision Machinery Innovation Technology Park is qualified to become a cluster for the EV industry. There are approximately more than 1000 precision machinery manufacturers and tens of thousands of suppliers that comprise an industry population greater than 470,000, accounting for 18% of the employed population, in the central region. The gross output or production value of the precision machinery industry will reach 905.8 billion dollars in 2012 and is an emerging trillion-dollar industry, according to data provided by the Industrial Economics and Knowledge Center of the Industrial Technology Research Institute. Upstream,

mid-stream, and downstream industries concentrate in Central Taiwan and the presence of neighboring schools and research institutions encourages the enhancement of research and development for technologies and the frequency of employee and personnel exchange, creating enhanced prospects for industry. The Taichung city government decided to make the Taichung Precision Machinery Innovation Technology Park an intelligent industry cluster (i-Park) after Taichung was named one of the top seven intelligent cities in the beginning of 2012. An intelligent industry service platform for Taichung precision machinery was planned for establishment and will provide companies and the public with a convenient information exchange platform for the promotion of applications such as intelligent energy saving. Based on the above analysis, our suggestions regarding industries are as follows.

- Advanced technologies imports and well-established environmental infrastructure:

The technology in the overall supply chains requires enhancement by providing favorable investment environments to attract investments from foreign hi-tech vendors, and by cultivating local enterprises by strengthening technology transfers through joint ventures. In addition, environmental infrastructure should be strengthened, including the wide-spread establishment of smart meters with bi-directional communication functions, to effectively restrict user loads. Furthermore, no negligence can occur if a smart grid is constructed that incorporates vehicle design, power supply, and electricity grid systems with overall planning. Kim et al. [26] argued that planning and investment for electricity distribution grids and infrastructure should begin as soon as possible. In addition, a well-planned intelligent energy management system (IEMS) is capable of ushering industries into mature and comprehensive stages, increasing opportunities for industry growth.

- Assembling industry clusters and providing rewards and incentives when appropriate:

Based on the aforementioned findings, the Taichung city government should construct an exchange platform for the EV industry and provide necessary technologies and up-to-date information to empower companies. It should also collect and post energy-related knowledge and disseminate information such as relevant websites. Furthermore, for the formation and development of the EV industry, the government should establish industry districts or park and rewards and conveniences such as free transportation and tax subsidies.

4.2.3. Laws and regulations

The RIA indicates that, for the Taichung city government to establish suitable policies and conduct administrative matters in accordance with the law, it should request that its subordinate organizations conduct evaluations on adaptation statements and legislation. These evaluations refer to lists in which affected areas, such as existing plans, activities, traffic or transportation, industrial environments, and land use, are organized based on analyses of various factors, including societal, economic, and industrial environments, from the perspectives of regulatory administration and supply administration. The regulatory administration for restricting traditional vehicles (e.g., restriction on carbon emissions for vehicles of a specific age, fees or taxes on vehicles older than a specific age) is to be regulated by self-government ordinances because, according to Article 28, Paragraph 2 of the Taiwan Local Government Act, "issues that create, deprive, or restrict the rights and duties of residents of local self-governing bodies" should be restricted by self-government ordinances. Comparatively, supply

administration regarding rewards or subsidies for the EV industry (e.g., the amount of subsidies, length of subsidies, and benefits or discounts given to EV consumers) should be based on interpretations No. 614 and No. 443 of the Justices of the Constitutional Court for the Judicial Yuan. Supply administration includes less restrictive legislation and does not require regulation by self-government ordinances.

Letcher [27] argued that governments, playing a critical role in traffic planning, should endeavor to solve issues of supply and operation such as externality and fairness. The State of California, for example, has limited the minimum tolerance of the environmental impacts of vehicles through legislation. Furthermore, the California Air Resources Board (CARB) has organized the California zero emissions vehicle (ZEV) program, which, through strict policies and legislation, has a goal of zero carbon emissions and seeks to reduce the level of greenhouse gas emissions to their levels before 1990 by 2050 [28].

To resolve the financial and legislative difficulties encountered by local governments, this study further suggests that the central government issue regulations and rewards through legislation. The Executive Yuan should establish and integrate regulations that can be followed by the entire country. To match the speed of technology's rapid development, related legislation should be more efficient in accommodating these changes than in other fields. Summarizing the above, this study's suggestions regarding laws and regulations are as follows.

- Establishment of an effective environment for policies and laws:

For newly proposed green industries to be successful, an amenable environment for investment and industry is essential. After communicating with relevant companies to understand their demands, governments should create enhanced environments for assistance and subsidies, increase the rewards for industry transformation, and actively establish relevant laws and regulations to legalize and standardize administrative work.

- Attention to the legality of the adoption of international and central government standards:

Central regulations and international treaties and conventions should always be observed in addition to the mentioned legislative demands for the supply administration regarding rewards and subsidies. Article 30, Paragraphs 1 and 2 of the Taiwan Local Government Act, in particular, should be complied with: "Self-government ordinances shall become invalid if contradictory to the Constitution, laws, regulations promulgated in accordance with law, or self-government ordinances of the superior self-governing bodies"; "Self-government regulations shall become invalid if contradictory to the Constitution, laws, regulations promulgated in accordance with law, self-government ordinances of the superior self-governing bodies, or the self-government ordinance of the self-governing body concerned." Overall planning for administration should comply with Articles 163 and 164 of the Administrative Procedure Act in accordance with the principle of "law-based administration."

5. Conclusion

In recent years, Taiwan has suffered from air pollution, especially in Central Taiwan. One of the major sources of pollution is the vehicle, causing a lot of PM2.5 pollutant. The monitoring

results of the daily average PM2.5 concentration for the Taichung area frequently reaches 80 μg/m^3 in 2017 winter, according to the data of the Environmental Protection Administration of Taiwan. The WHO standard for the daily average has been established as less than 25 μg/m^3. This type of highly concentrated air pollution has caused damage to the environment and people. Consequently, the Taiwan government is now attempting to reduce the air pollution concentrations in the Taichung area using various methods, and energy consumption is expected to decrease because of the inducement of tax reform incentives and environmental improvements. The development of the utilization of, and subsidies for, electric motorcycles in Taiwan has matured, and Taichung is the most active city in Taiwan striving for EV development. In November 2017, Taiwan's Transport Minister announced that it will replace gasoline vehicles with electric vehicles by 2040 [29]. In the future, Taichung should appropriately employ its advantageous position in Central Taiwan and assemble mature precision machinery suppliers in the area to plan the construction of energy-saving facilities and to cultivate the EV industry. By doing so, Taichung will benefit its citizens and improve Central Taiwan's overall development. After development, the theory of paradigm shifts must be employed, allowing the empirical experience of Taichung to serve as a reference for the development of EV industries and the establishment of EV clusters in emerging cities in developing countries with similar environments and conditions.

5.1. Research limitations and suggestions for future research

Due to relevant limitations, this study was only able to perform analyses through the perspectives of law, public administration, and management, neglecting analytical models in other disciplines and fields. We believe that interdisciplinary research methods can overcome the limitations of traditional research methods that are based on a single academic discipline. However, this research approach lacks quantitative analyses and cannot provide thorough statistics regarding EV development in Taichung.

Furthermore, as an emerging industry, the EV industry displays insufficiency in its independent developmental potential and requires improvement and expansion in its transitional stage and product positioning (e.g., current hybrid vehicles). Although there is an increasing amount of relevant essays being published, studies on zero-emission EVs, particularly on EVs in Taiwan, are scant. This study succeeded in employing the mentioned research methods and conducting interdisciplinary research, but failed to make parallel comparisons between the background factors of developing cities and countries of a similar scale. Various differences, such as those between local and unique customs and traditions or laws and regulations, can be integrated in future related research.

Author details

Li-Min Cheng

Address all correspondence to: lawlimin@gmail.com

Department of International Business, Providence University, Taiwan, ROC

References

[1] Calef D, Goble R. The allure of technology: How France and California promoted electric and hybrid vehicles to reduse urban air pollution. Policy Sciences. 2007;**40**(1):1-34

[2] McElroy MB. Energy: Perspective, Problems, and Prospects. London: Oxford University Press; 2009. p. 424

[3] Coelho MC, Farias TL, Rouphai NM. A numerical tool for estimating pollutant emissions and vehicles performance in traffic interruptions on urban corridors. International Journal of Sustainable Transportation. 2009;**3**(4):246-262

[4] Rothwell R, Zegveld W. Industrial Innovation and Public Policy Preparing for the 1980s and the 1990s. London: Frances Printer; 1981

[5] Porter ME. The Competitive Advantages of Nations. New York: Free Press; 1990. p. 875

[6] Kotval Z, Mullin J. The potential for planning an industrial cluster in Barre, Vermont: A case of 'Hard-Rock' resistance in the granite industry. Planning Practice and Research. 1998;**13**(3):311-318

[7] Simmie J, Sennett j. Innovative clusters: Global or local linkages? National Institute Economic Review. 1999;**170**(1):87-98

[8] Schmitz H. Does local co-operation matter? Evidence from industrial clusters in South Asia and Latin America. Oxford Development Studies. 2000;**28**:323-336

[9] Knorringa P. Agra: An old cluster facing the new competition. World Development. 1999; **27**(9):1587-1604

[10] Chen JY. A study on the competition law of the energy industries. Fair Trade Quarterly. 2012;**20**(3):85-128

[11] Elliott D. Sustainable Energy: Opportunities and Limitations (Energy, Climate and the Environment). UK: Palgrave Macmillan; 2007. p. 285. DOI: 10.1057/9780230378384

[12] Wengenmayr R, Buhrke T. Renewable Energy: Sustainable Energy Concepts for the Future. 1st ed. Wiley-VCH; 2008. p. 120

[13] Ellig J, McLaughlin PA. The quality and use of regulatory analysis in 2008. Risk Analysis. 2012;**32**(5):855-880

[14] Harrington W, Heinzerling L, Morgenstern RD. Reforming Regulatory Impact Analysis, Resources for the Future. 1st ed. Washington, DC: Lightning Source Inc.; 2009. p. 242

[15] Morrall JF. Regulatory Impact Analysis: Efficiency, Accountability and Transparency. US Office of Management and Budget: Washington, DC; 2001

[16] Staronova K, Pavel J, Krapez K. Piloting regulatory impact assessment: A comparative analysis of the Czech Repulic, Slovaka and Slovenia. Impact Assessment and Project Appraisal. 2007;**25**(4):259-269

[17] Hertin J, Jacob K, Pesch U, Pacchi C. The production and use of knowledge in regulatory impact assessment – An empirical analysis. Forest Policy and Economics. 2009; **11**(5-6):413-421

[18] Noland RB. Transport planning and environmental assessment: Implication of induced traveal effects. International Journal of Sustainable Transprotation. 2007;**1**(1):1-28

[19] IPCC-Intergovernmental Panel on Climate Change. Available from: http://ipcc.ch/ [Accessed: 2017-12-10]

[20] Boyer K, Verma R. Operations and Supply Chain Management for the 21st Century. Cengage Learning; 2009. p. 592

[21] Greenhalgh C, Rogers M. Innovation Intellectual Property, and Economic Growth. Princeton University Press; 2010. p. 384

[22] TUV Rheinland. Available from: http://www.tuv.com/en/corporate/home.jsp [Accessed: 2017-12-10]

[23] Better Place. Available from: http://www.betterplace.com [Accessed: 2016-4-16]

[24] Alliance for Wireless Power. Available from: http://www.a4wp.org/ [Accessed: 2017-12-10]

[25] Plugless Power. Available from: http://www.pluglesspower.com/go-plugless [Accessed: 2017-5-10]

[26] Kim J, Rahimi M, Newell J. Life-cycle emissions from port electrification: A case study of cargo handling tractors at the Port of Los Angeles. International Journal of Sustainable Transportation. 2012;**6**(6):321-337

[27] Letcher T. Future Energy: Improved, Sustainable and Clean Options for our Planet. 2nd ed. Elsevier; 2013. p. 738

[28] California Energy Commission. 2007 Integrated Energy Policy Report [Internet]. Available from: http://www.energy.ca.gov/2007_energypolicy/ [Accessed: 2017-12-10]

[29] Radio Taiwan International. Full EV in Taiwan by 2040 [Internet]. Available from: http://news.rti.org.tw/news/detail/?_lang=zh-tw&recirdld=382211&p=27 [Accessed: 2017-12-10]