

A Quantitative Study on the Regional Patterns of China's Light Emitting Diode Industry Policy

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Abstract--This paper studies the regional patterns of China's light emitting diode industry policy. The paper gathers policy contexts of the central government, Guangdong Province, Fujian Province and Jiangxi Province. By policy bibliometrics analysis and content analysis of the policy context's external and internal characteristics, the paper explores the regional patterns on the policy-making time, policy-making agency and policy tool and discusses the relationship between policy orientation and the reality of industry development in various regions. The paper finds that there exist differences on the frequency of policy-making time and the administrative departments. Particularly, there are remarkable differences on the aims, emphases, means and valid period of policy tools. The analysis framework and method are applicable to the research of other industry policy, and the conclusion may be supportive to the authorities on policy making.

I. INTRODUCTION

Light emitting diode (LED) is a kind of solid-state semiconductor devices which have the advantages of saving energy, protecting environment, having a long life, producing low heat and so forth. It is able to convert electric energy into visible light. In recent years, driven by the continual investment of R&D and the market demand, China's LED industry has achieved a rapid development. According to statistics from China solid state lighting alliance, the output value of China's LED industry was 345 billion RMB Yuan in 2014, increasing by 31% from the year of 2013. China has already become a significant global center in R&D, production and consumption of LED industry, and some main industrial areas are formed, such as the Pearl River delta, the Yangtze River delta, the Min delta (Fujian Province), and so forth. Through continuous tracking of the industry, we find that enterprises of the Pearl River Delta are more concentrated in the middle and the downstream of the industry chain, focusing on packaging and light applications; while enterprises of the Min Delta are more concentrated in the upstream of the industry chain, focusing on epitaxy and chip production. Whether there is a certain correlation between different industry development characteristics and different industry policy of local governments, and how to plan the layout and orientation of the local industry policy to further promote the optimization and upgrading of the industry is an urgent problem that needs to be considered.

The fact that both the central and local governments are China's industrial policy-making agency renders certain differences in the relevant industrial policy contexts. Normally, the central government makes decisions from an

overall point of view, while local governments tend to be practical on policymaking. The policy differences reflect the diversity of policy goals, ideas and means of the central and local governments in promoting industrial development process.

Based on the regional differences in LED industry development, we collect the relevant industry policies issued by the central government, and the local governments in Guangdong, Fujian and Jiangxi Provinces. By quantitative analysis of the policy context's external and internal characteristics, and taking the central government policy as a reference, the paper investigates the regional differences on the policy-making time, policy-making agency and policy tool among the above said three provinces, namely, Guangdong, Fujian and Jiangxi. The paper also tries to explore whether the industrial policy can influence the local industrial development patterns and characteristics. By studying regional patterns of industry policy, on the one hand, it helps to understand how local governments combine the central government's overall plan and layout for industry development with local industry development characteristics and advantages to carry out targeted policy layout; on the other hand, by digging different strategies and means adopted by all levels of governments in promoting industrial development process, the paper hopes to provide support for the further development of industry-related policies.

In recent years, most research in the area of policy patterns concentrated on comparative analysis of a specific policy, involving the differences on policy-making agency, policy goal and policy influence. Steurer et al. [1] analyzed the differences on the themes and instruments of public policies on corporate social responsibility in Europe. Betsy et al. [2] discussed similarities and differences in stakeholding in drug user opioid substitution treatment policy between Britain, Denmark, Italy, Austria, Poland and Finland. Philippe et al. [3] analyzed the differences on financial aid policies between the United States and Canada, and discussed whether it can influence the relationship between family income and post-secondary attendance. Hardy and Woodcock [4] analyzed the differences on policy of inclusive education between the United States, Canada, England and Australia by employing a broadly critical policy sociology approach. As to the study related to the policy tools, the main research grew up accompanied with the diversification of public management subject and the rise of the complexity and executive difficulty of the public [5][6][7][8][9]. Furthermore, many scholars have carried out a lot of research

on the types of policy tools [10][11][12][13][14][15]. Rothwell and Zegveld [16] divided the technology innovation policy tools into supply side policy tools, demand side policy tools and environment side policy tools based on the policy impact level on technology. Su [17] carried out further refinement and expansion on Rothwell framework. As for the research on LED industry, Choi and Seongrak [18] concluded that lacking of original technology is the main problems that hinder the development of LED industry in South Korea. Zhao et al [19] gave an in-depth analysis on the practice of energy management contract (EMC) and benchmark system in Guangdong Province of China. Sanderson and Simons [20] draws lessons on industry emergence, by analyzing how a solid-state lighting (SSL) industry grew out of LED technologies. Hu et al. [21] explored the influence of the technological regime on the global light-emitting diode industry. Parker [22] believed that LED technology is quickly becoming the de facto standard for energy efficient and quality lighting.

II. DATA COLLECTION AND METHODOLOGY

A. Data collection

To investigate the regional patterns of China’s LED industry policy, the paper selects Guangdong, Fujian and Jiangxi Provinces as the local government analysis objects, for the three provinces are superiority province of LED industry development. Based on the Government Document Information (GDIS) Database of Tsinghua University and government websites, the paper collects the LED industry

policy from January 2007 to December 2015. After data cleaning, the paper builds a database of China’s local LED industry policy documents, consisting of 530 documents, among which the central government has 183, Guangdong 174, Fujian 105, and Jiangxi 68. The data fields of the database include policy-making time, policy title, policy-making agency and full policy contexts.

B. Methodology

The paper utilizes policy bibliometrics and policy content analysis to conduct a quantitative analysis of China’s LED industry policy. As mentioned above, policy bibliometrics is a quantitative analysis method on the policy’s external characteristics. The paper focuses on the differences in policy-making time and policy-making agency of LED industry to carry out a comparative analysis. The policy-making time and policy-making agency are the important parts of policy context’s basic information. By the analysis of policy-making time, it helps to understand the distribution and characteristics of LED industry policy context in the time dimension. By the analysis of policy-making agency, it helps to analyze which departments exert the main leading role or have a cooperation to promote LED industry development in different regions. Policy content analysis focuses on the policy context’s content. Based on the classification of policy tools, each item of LED industry policy context’s content is encoded. We invite some experts to conduct variance analysis on coding each LED industry policy document. The research framework is shown in Figure 1.

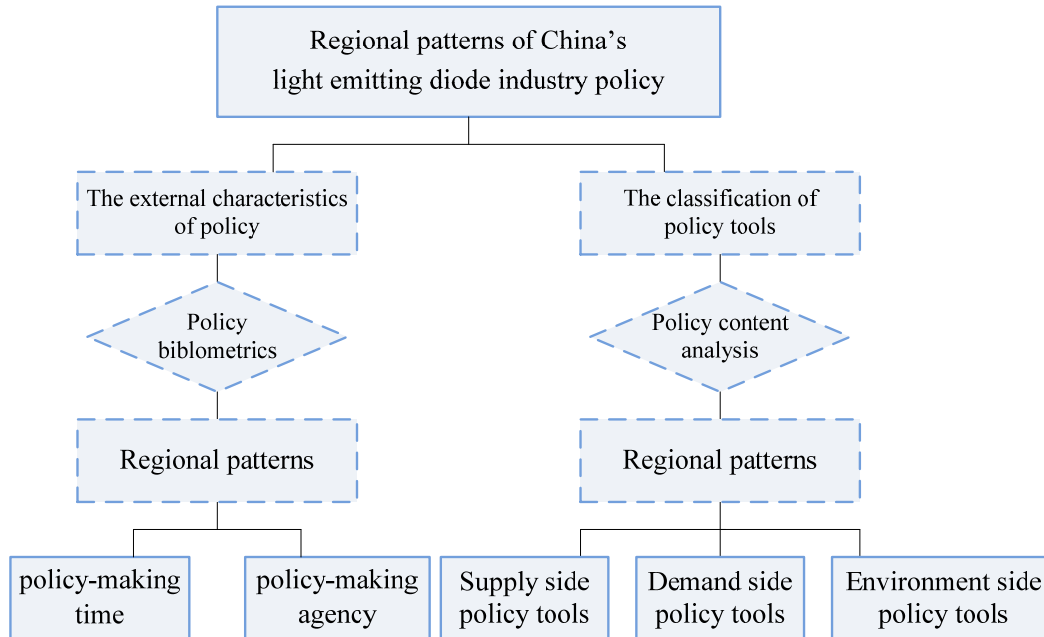


Figure 1 The research framework

III. REGIONAL PATTERNS OF CHINA'S LED INDUSTRY POLICY

A. Regional patterns in policy-making time

The distribution of the policy-making time is shown in Figure 2 (where the size of the dot indicates the number of policies). The peak period of the central government's policy-making was from 2011 to 2013, when a series of policies for the development strategies of LED industry, industry standards, energy conservation management and other aspects were promulgated. The peak period of Guangdong LED industry policy-making was from 2010 to 2012, especially from 2009 to 2010, when the number of policies rose from 9 to 40, with an increase up to 344.4%. Fujian's policy-making time was mainly 2011 and 2012. Policy-making peak of Jiangxi was from 2009 to 2011, but the number of policies gradually reduced since the beginning of 2012. The most noticeable thing as shown in Figure 2 is that the numbers of policies issued by different governments are significantly different; the number of policies made by the central government and Guangdong is significantly higher than the others. The second point worth noticing is that the

burst point of policy growth is also different: the starting year of the central government and Fujian was 2011, Guangdong was 2010, and Jiangxi was 2009.

B. Regional patterns in policy-making agency

Figure 3 shows the top 3 policy-making agencies according to the number of policies of the central government, and Guangdong, Fujian and Jiangxi Provinces. The top 3 policy-making agencies of the central government are the National Standardization Administration Committee (39), the Ministry of Science and Technology (31) and the Ministry of Industry and Information (30); the top 3 policy-making agencies of Guangdong are the Provincial Science and Technology Agency (84), the Provincial Government (38) and the Provincial Economic and Information Technology Commission (30); the top 3 policy-making agencies of Fujian are the Provincial Government (56), the Provincial Science and Technology Agency (12) and the Provincial Economic and Trade Commission (11); the top 3 policy-making agencies of Jiangxi are the Provincial Development and Reform Commission (29), the Provincial Government (29) and the Provincial Department of Transportation (4).

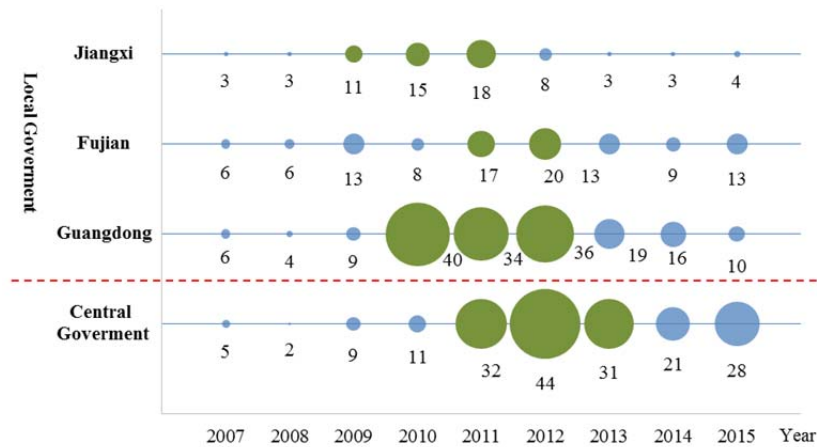


Figure 2 Regional patterns in policy-making time from 2007 to 2014

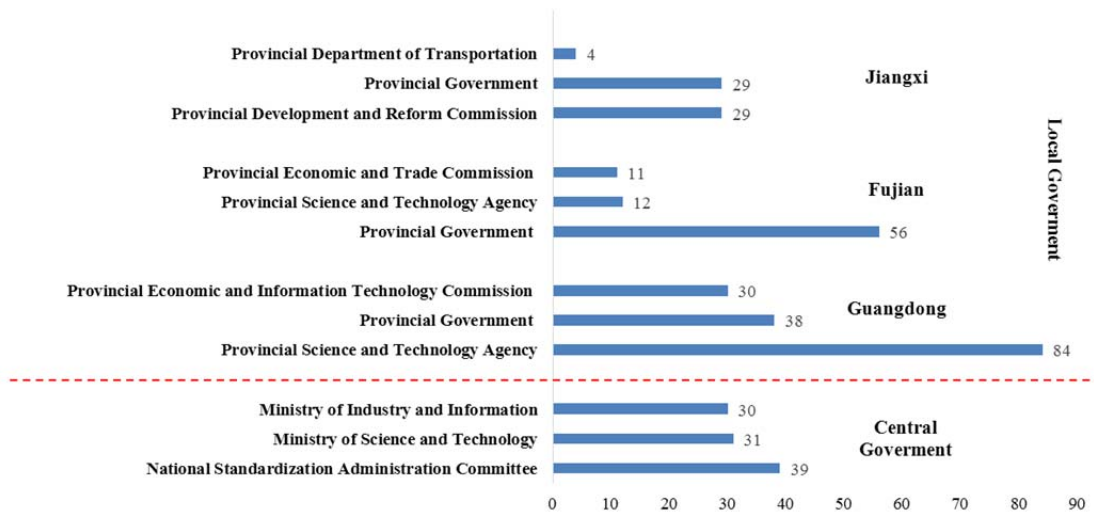


Figure 3 Regional patterns in policy-making agency

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The different policy-making agencies demonstrate that the departments leading and managing the development of LED industry vary from region to region. At the central government level, the Ministry of Science and Technology, the Ministry of Industry and information, and the National Standards Commission play a significant role. At local government levels, the competent departments of LED industry in different provinces have significant differences. The Science and Technology Department of Guangdong has played a significant role in overall planning and management in the development of Guangdong LED industry; the number of policy is much higher than other departments. The Fujian Provincial Government is the main guide for the development of Fujian LED industry; the number of policy is also far higher than other departments. The Jiangxi Provincial Development and Reform Commission and the Provincial Government make the policies that related to LED industry together, where there is no significant difference.

C. Regional patterns in policy tools

Policy tools can be divided into the supply side policy tools, the demand side policy tools and the environment side

policy tools[16][17]. Table 1 shows the specific meaning and the sub types of policy tools.

Table 2 shows an obvious difference between the central government and local governments in terms of policy tools. The central government uses the environment side policy tools most, then the supply side policy tools and the demand side policy tool at least. On the contrary, what Guangdong, Fujian and Jiangxi use most are supply side policy tools and the tools are used in a proportion much higher than the environment side policy tools; the demand side policy tools take the smallest proportion of policy tools, the same as the central government.

1) Regional patterns in supply side policy tools

Table 3 and Figure 4 respectively show the number and the proportion of the sub type of LED industrial supply side policy tools. The "science and technology funding" policy tool is the mostly used tool in Guangdong and Fujian (especially in Fujian, accounting for 51.9% of its total policy tools).

TABLE 1 CLASSIFICATION AND DEFINITION OF POLICY TOOL

Classification	Definition	Sub-classification
Supply side	The government directly expands the supply of technology, improves the supply of the relevant factors of technological innovation, promotes technological innovation and new product development through the means of personnel, information, technology and capital.	Education and training, technology information support, technology infrastructure construction, science and technology funding, public service.
Demand side	The government reduces the uncertainty of market by procurement and trade control, and actively explores new technologies and stable market, thus boost technological innovation and new product development.	Public technology procurement, demonstration project, consumer side subsidy, service outsourcing, trade control and overseas institution management.
Environment side	The government influences the Environmental factors of technology development through finance, the tax system, regulatory control and other policies, providing an enabling policy environment for the industrial technology innovation, indirect promoting the technological innovation and new product development.	Goal planning, financial support, tax preference, intellectual property protection, regulatory control.

TABLE 2 BASIC CLASSIFICATION DISTRIBUTION OF LED INDUSTRY POLICY TOOLS

Classification	Central Government		Guangdong		Fujian		Jiangxi	
	#	%	#	%	#	%	#	%
Supply side	77	33.9	201	58.8	81	58.7	78	58.2
Demand side	14	6.2	52	15.2	12	8.7	18	13.4
Environment side	136	59.9	89	26.0	45	32.6	38	28.4
Total	227	100.0	342	100.0	138	100.0	134	100.0

TABLE 3 THE NUMBER DISTRIBUTION OF THE SUB-CLASSIFICATION OF LED SUPPLY SIDE POLICY TOOLS

Sub-classification	Central Government	Guangdong	Fujian	Jiangxi
Public service	16	49	14	44
Technology information support	14	40	7	5
Science and technology funding	35	73	42	14
Technology infrastructure construction	6	20	11	10
Education and training	6	19	7	5
Total (#)	77	201	81	78

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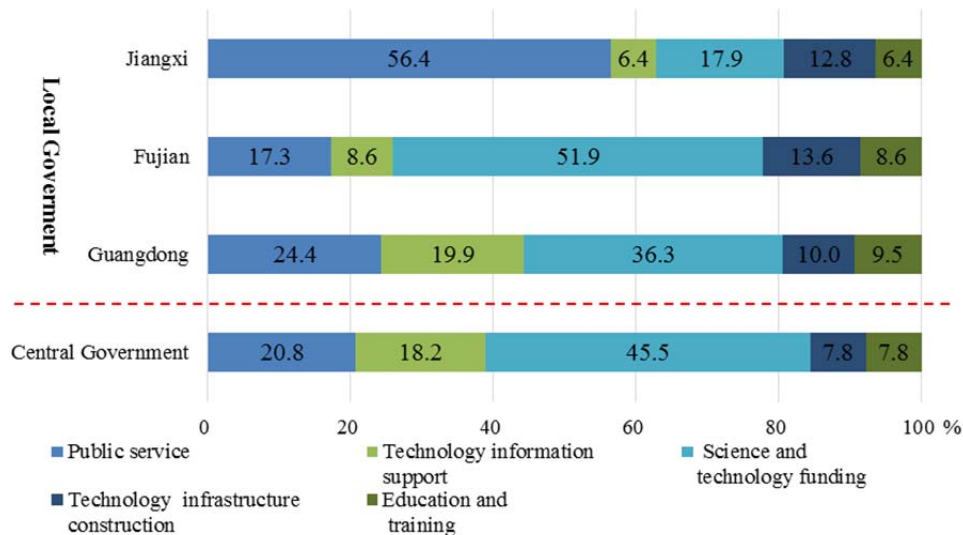


Figure 4 The proportion distribution of the sub-classification of LED supply side policy tools

There is a significant difference between the local governments in terms of the use of “science and technology funding” tools. Guangdong continued to increase efforts to support the LED industry, and implemented a series of financial subsidy policies to attract more capital to support LED industrial development since 2007. By 2014, subsidies for energy-saving lamps gradually shifted to the LED lights. In this process, Guangdong set up a number of financial support and subsidy programs for enterprises. In addition to major industrial projects funds of LED chip production project, MOCVD equipment research and development subsidies, LED production line and other government subsidies that related to assets, the government also set up subsidies award for research and development and technology innovation, provincial financial subsidies, subsidies for imported equipment, imported equipment discount, key enterprises project grants and income-related government subsidies. The investment for chip and key equipment in Guangdong also related to the focus on the development of its weak upstream of LED industry currently.

Fujian proposed to “increase the development and production of the full range of LED epitaxial and chip, and develop packaging and downstream applications” in the “Investment priority of industry restructuring and revitalization plan” in 2009, in which the investment priority covered the whole industry chain. In early 2014, the support program that focused on LED leading enterprises of Fujian pointed out that “we endeavor to break through the high power wafer and chip manufacturing, high-performance LED packaging and driving power, LED lighting design, large-size LED backlight and other key technology”. The priority of development has gradually concentrated on the downstream and upstream of LED industry.

Jiangxi’s LED industrial capital is mainly invested into the upstream of the industry chain from 2007 to 2009, in order to help phosphor and chip production, and support the

production of Jiangxi optoelectronic Co., Ltd, which mainly produces LED chip products. Subsequently, the “Jiangxi Province industry and information technology development plan for 2010 to 2015” issued by Jiangxi Province in January 2012 proposed to “develop downstream applications of LED industry chain”. Later in April 2012, the Jiangxi Provincial Development and Reform Commission issued “A number of views of guiding and promoting strategic emerging industries” and again made it clear that “we will give the key support to the silicon substrate-based LED epitaxial chip industry and focus on the development of the downstream technology applications and LED products to extend the industrial chain”. It can also be seen that LED development strategy has changed in Jiangxi.

On one hand, financial support from the government can help companies expand production scale and improve technical content; on the other hand, it can also reduce the price of LED products, promote enterprises development, supply capital chain and extend LED products. However, the strong support for a small part of LED enterprises by local governments often make LED prices fall sharply and indirectly lead to unfair market competition to some enterprises; in addition, some enterprises may pay most attention to making good use of the government policy, rather than technology development and product quality improvement. The unhealthy competition in the market is the adverse effect of the government policy support.

2) Regional pattern in demand side policy tools

Table 4 and Figure 5 respectively show the number and the proportion of the sub types of LED industrial supply policy tools. As a whole, the proportion of the demand policy is low and the policy tools are relatively simple, the main policy tools include “demonstration project”, “public technology procurement” and “consumer side subsidy”.

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TABLE 4 THE NUMBER DISTRIBUTION OF THE SUB-CLASSIFICATION OF LED DEMAND SIDE POLICY TOOLS

Sub-classification	Central Government	Guangdong	Fujian	Jiangxi
Public technology procurement	3	18	8	10
Overseas institutional management		1		
Demonstration project	3	25	4	5
Consumer side subsidy	8	5		3
Service outsourcing		3		
Total (#)	14	52	12	18

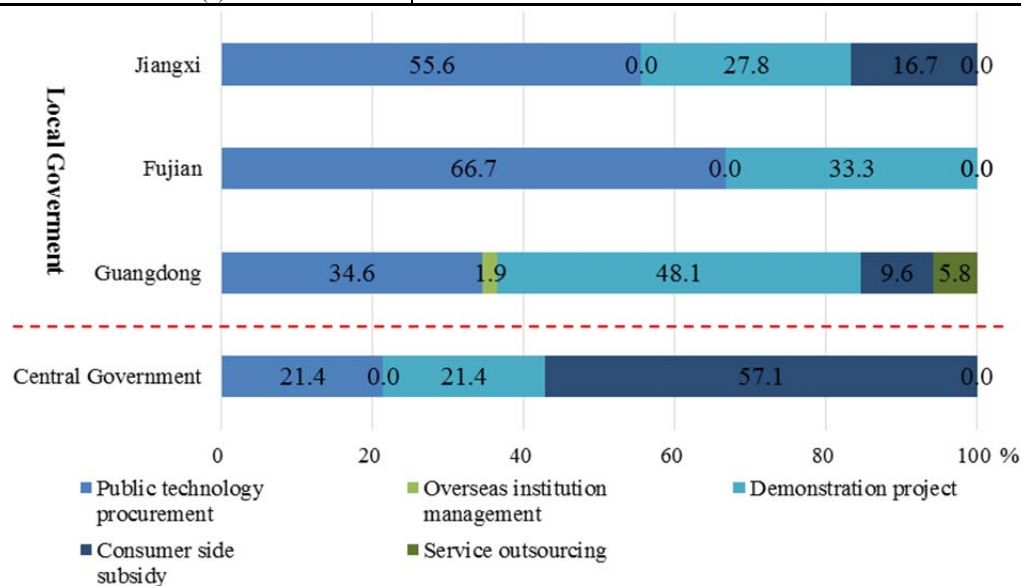


Figure 5 The proportion distribution of the sub-classification of LED demand side policy tools

From the perspective of "demonstration project" tool, at the central government level, the Ministry of Science and technology organized the "Ten City Ten Thousand Lights" LED application engineering experimental work in April 2009, in two batches approved 37 pilot cities to promote application development, actively guided and fostered LED application market. At the local level, the "demonstration project" tool was used by Fujian, Jiangxi after 2009, and the majority of policies were closely related to "Ten City Ten Thousand Lights". For example, in response to "Ten City Ten Thousand Lights", the Fujian government also designated a national "Ten City Ten Thousand Lights" LED application demonstration city in that year, and initiated the green lighting demonstration project in 2011. Jiangxi's "demonstration project" tool appeared as a branch entry of comprehensive policy contexts; the main policy objective was to coordinate with the national "Ten City Ten Thousand Lights" project and boost LED industry development. In contrast, Guangdong launched a green lighting project in 2007. The "Economic and Trade Commission of Guangdong Province on the notice of issuing long-term special planning of energy-saving in Guangdong Province" proposed the policy objectives of "promoting the development of new lighting technologies, new products and new lighting design, accelerating efficient energy-saving system reform of factories, enterprises, municipal landscape lighting, office buildings, public facilities, etc.". The project was deployed

ahead of the central government policies. Guangdong started "Thousand Meters One hundred Thousand" high-power LED street lamp demonstration project in December 2008 to promote green lighting products, six months earlier than the "Ten City Ten Thousand Lights" project of the Ministry of Science.

The central government and local governments have different choices in "public technology procurement" and "consumer side subsidy". Both policy tools help promote LED products in policy objective. For the central government, the Ministry of Finance and the National Development and Reform Commission issued "financial subsidies fund management Interim Measures for promoting efficient lighting products," and other relevant policies in 2007, and clearly stated that "the subsidies fund take the way of indirect subsidies, subsidies to bid enterprises by financial, then bid enterprises sales product to the end users in a price that equal to the result of the bid price agreement minus financial subsidies fund, bulk users, urban and rural residents are the ultimate beneficiary". The three provincial governments generally focus on the use of "public technology procurement" tools. For example, Guangdong has continuously issued the "Recommended purchasing products Catalog of green lighting model city in Guangdong Province" since 2011, and pointed out that "we will seriously implement the national policy of energy saving products government procurement". Fujian's Provincial Department of Finance,

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TABLE 5 THE NUMBER DISTRIBUTION OF THE SUB-CLASSIFICATION OF LED ENVIRONMENT SIDE POLICY TOOLS

Sub type	Central Government	Guangdong	Fujian	Jiangxi
Goal planning	28	38	23	18
Financial support	5	13	1	7
Regulatory control	84	17	4	4
Intellectual property protection	15	16	16	4
Tax preference	4	5	1	5
Total (#)	136	89	45	38

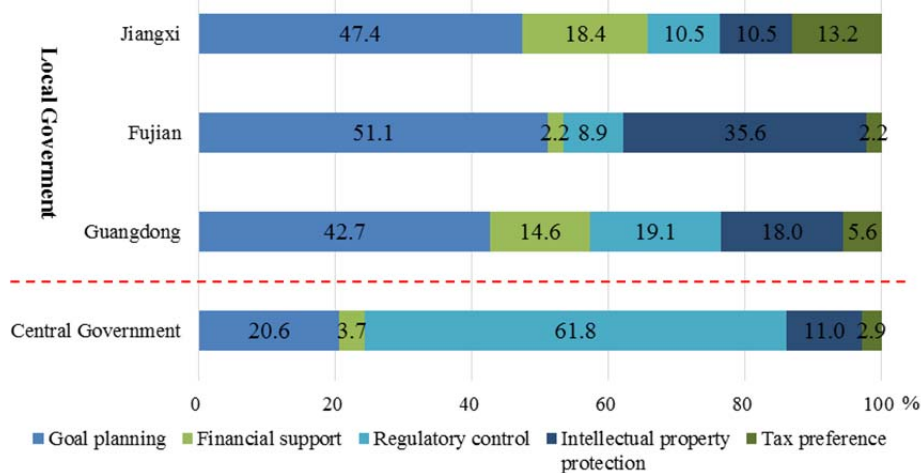


Figure 6 The proportion distribution of the sub-classification of LED environment side policy tools

the Provincial Economic and Trade Commission and other departments jointly issued the "Fujian Province government procurement list of energy-saving, environmental labeling and independent innovation products". The Development and Reform Commission of Jiangxi Province issued the "Recommended Catalog of energy-saving products and technology in Jiangxi Province"; the Jiangxi Provincial people's Government General Office published the "Government procurement catalog and standards in 2014" in order to promote the extension of LED products.

3) Regional pattern in environment side policy tools

Table 5 and Figure 6 respectively show the number and proportion of the sub types of LED industrial Environment side policy tools. The central government mainly uses "regulatory control", including promulgating and filing various industry standards, national standards, accounting for 61.8% of all environment side policy tools.

In contrast, the common ground of the local provincial environment side policy tools is to focus on the specific goals and plans. Represented by Guangdong province, the LED Industry Development Planning is integrated with the overall strategic planning of the province, such as Strategic Emerging Industry Development Plan, the Pearl River Delta Development Plan, Technical Innovation Plan, Patent Technology Implementation Plan etc. On the other hand, the local environmental policy tools of the three provinces also have their own characteristics. Guangdong Province promulgated the "Local standards of LED street lamps in Guangdong Province", "Standard system planning and road

map for LED lighting industry (2011-2015)", "Guangdong Province LED lighting standard optical module project implementation plan" and other policies, and at the same time proposed to promote the construction of the benchmark system in "Several opinions on accelerating the transformation of economic development mode" and "Notification on promoting appliance LED lighting product evaluation benchmark system". Fujian attached particular importance to the protection of intellectual property, setting up a series of special incentives for businesses and research institutions to encourage R&D and technological innovation, such as "Provincial outstanding new products award", "Patent award in Fujian", and "Famous brand".

IV. CONCLUSIONS AND DISCUSSION

After exploring the regional patterns on the policy-making time, policy-making agency and policy tools of China's LED industry policy, we summarize the conclusion as follows:

In respect of policy-making time, there are differences in the year of the initial promulgation and the intensity of the promulgation of policies between the central government and local governments, as well as between the local governments themselves. The central government policy-intensive year is 2011 to 2013, Guangdong and Jiangxi respectively is 2009 and 2010, earlier than the central government, and Fujian promulgated policies mainly in 2011 and 2012.

In respect of policy-making agency, at the central government level, the Ministry of Science and Technology, the Ministry and the National Standardization Management

Committee are main departments to promulgate policy. Significant differences exist in local government's policy-making agency, for the centralized management departments for the LED industry are different in each province. For instance, the LED industry is led by the Guangdong Provincial Science and Technology Management in Guangdong, but in the other provinces, it is led by different institutions.

In respect of policy tools, the central government and local governments have different choices, which reflect the different roles of the two levels' governments in leading industry development. Environment side policy tools are more used by the central government, while supply policy tools are more used by the local governments. For the use of supply side policy tools, technology capital investment tool are more used by the central government, Guangdong and Fujian. For the use of demand side policy tools, the more used tools are "demonstration project", "public technology procurement" and "consumer side subsidy". Among them, the time of the use of "demonstration project" tool is different for central government and local governments; the layout of Guangdong is earlier than the central government, while other provinces mainly implement related policy layout of the central government. The central government more focuses on the use of "consumer side subsidy" tool, however, local governments more focus on the use of "public technology procurement" tool. For the use of environment side policy tools, the central government mainly uses "regulatory control", which includes promulgating and filing various industry standards and national standards, but the local governments focus more on proposing specific goals and plans.

Industrial policy differences between the central and local governments reflect the diversity of policy goals and ideas of the central and local governments in promoting industrial development process; industrial policy differences among local governments have effect on the regional industrial development patterns and characteristics. In addition to implementing the central government policy, local governments still need to focus on the local industrial development characteristics, have a comprehensive consideration on the limitation of technology, talent, and capital on industrial development, and promulgate the specific industrial development policy. After the current research, how to prove the results of quantitative analysis with case analysis, how to determine the quantitative results of a specific policy tools, and how to ensure the scientific nature of the policy collection and the scientific and reasonable of policy tool classification remain as problems worth further studying.

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