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How Will Different Types of Regional Innovation Policy and Their Mixes Affect the Innovation Performance of Enterprises: An Empirical Study Based on Shenzhen

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Abstract

Evaluating the functional boundary of different types of innovation policy instruments and their mixes on innovation performance of enterprises is an important but unresolved key issue. This paper, based on the systematically carding the quantization of 155 innovation policies issued by Shenzhen governmental departments from 2011 to 2019, analyzed the characteristics from different types of innovation instruments and their mixes. The results show that Shenzhen governmental has constantly enriched innovation policy instruments for encouraging enterprise innovation, but there are structural unbalances in the issued innovation policy manifested as follows: firstly supply-side policy and environmental-side policy were promulgated more than demand-side policy; secondly the specific instruments employed by Shenzhen governmental were also uneven in different type of innovation policy, like supply-side policy focused on the instruments of government procurement and R&D outsourcing, demand-side policy employed human resource training, innovation infrastructure and fiscal support most, and environmental-side policy main used target planning, intellectual property protection and financial support. This study expands and understanding empirical implementation of different reginal innovation policy instruments, and has implication for Shenzhen governmental in improving the applicability ability of policies in the enterprises innovation.

Keywords: Regional Innovation Policy; Policy Instruments; Policy Mix; Innovation Performance

1 INTRODUCTION

Enhancing the innovation ability of enterprises is the key to implementing sustainable innovation-driven development of regional. Although market can drive the continuity of a firm's innovation, the risk of market failure would provide insufficient incentive. Therefore, governments' involvement in firm innovation activities and the formulation of innovation policies are important means to promote enterprise innovation performance (Glaeser and Cottleib, 2008) [1]. Since the 1990s, the Shenzhen Municipal Government has gradually promulgated innovation policies to encourage technological innovation development, which has been supplemented and adjusted gradually according the development of Shenzhen's technological changes. At present, innovation policies have become the main effective means for Shenzhen government to intervene in innovation development (Zhou Jianghua et al., 2017) [2], and plays an important role in promoting the transformation of technological achievements and promoting enterprise innovation activities. As the Shenzhen municipal government pays more and more attention to guiding the optimal allocation of all-round and whole-process innovation resources, the coverage of innovation policies continues to expand and policy instruments continue to enrich, which finally has developed into a complex policy system. As a result, innovation policies are no longer independent, but rely more on the systematization and complementarity among policies which would exert more strengthen on enterprise innovation behaviors (Liu Jing, 2021) [3]. Therefore, it is urgent to conduct

a systematic, effective and scientific in-depth analysis of the existing regional innovation policies, then propose future policy optimization for innovations, which is aim to give better play to the role of local government innovation policies and improve the accuracy of regional incentives for enterprise innovation.

Based on this, this paper would take Shenzhen's innovation policies from 2011 to 2019 as the research object, and based on the quantification of policy, we will reveal the characteristics and existing problems of Shenzhen's innovation policies from the aspect of the different types of policy instruments and their mixes. Furthermore, the reasonable and effective suggestions in the policy selection, combination and construction would be promoted for the Shenzhen government.

2 LITERATURE REVIEW

Facing the changing enterprise innovation activities, local government authorities constantly expand different policy instruments in design, collocation, mix and application, which focus on optimize the allocation of limited innovation resources and promoting enterprise innovation (Nemet, 2009) [4]. Thus, there are some researches to classify policies. Rothwall and Zegveld (1981), and Peters et al. (2012) [5] indicated that government's objectives are to create favorable conditions for innovation on the supply-side, demand-side and environmental-side through policy support. And Woolthuis (2005) [6] classified innovation policies into informational, authoritative, organizational and financial categories. Hoppmann (2013) [7] divided policies into strategic layer, comprehensive layer and basic layer.

Furthermore, following the increasing of policy instruments, scholars expanded studies on innovation policies measures. Helfand (2002) [8] considered innovation policies involving four categories including R&D support, technology transfer, innovation bottleneck breakthrough and system innovation according to the three functions of innovation evolution. Then based on the market failure, planning and cooperation of reginal innovation, Ekbior (2003) [9] specified regional innovation policies into direct investment policies, indirect support policies and peripheral promotion policies. Then Zhou Rui et al. (2011) [10] listed 10 categories of reginal innovation policy including technology investment, taxation support, financial support, and talent teams training. As well as Zhang Yongan et al., (2012) [11] classified regional innovation policies into six categories: information, enterprise orientation, encouragement of collaboration, training, service support, and innovation agglomeration. In general, the instruments of innovation policy selected by governments mainly including government procurement, financial subsidies, taxation support and patent protection.

Although, previous studies point out the types of innovation policy instruments for the reginal innovation and identified the factors in influencing the effect of innovation policies, there are still many problems. Firstly, regional innovation policy should not be single, different types of innovation policies may have different impacts on the innovation performance of enterprises, but there is currently a lack of systematic understanding of virous types of innovation policy instruments for reginal innovation and the effect-deviation in the implementation of different policy instruments. Secondly, a mismatching phenomenon of "goal-instruments" is existing during the implementation of reginal innovation policies to some extent, and not all innovation policy instruments have effectively promoted enterprises' innovation. In view this, this paper takes Shenzhen innovation policy as the research object, and try to identify different impact of policy instruments of Shenzhen on innovation of micro-enterprises based on the systematically carding the quantization of 155 innovation policies, which plays a significant role in terms of the academic value and the policy implication when understanding the interaction between the government and enterprises, making comments on the effect of the policy implementation and making arrangements for the action mechanism during the process of implementing innovation policies of Shenzhen.

3 RESEARCH DESIGN

3.1 Sample of Shenzhen Innovation Policies

This paper collected the innovation policy items from innovation policies issued by Shenzhen government ministries from 2011 to 2019. The innovation policies collected from Shenzhen government ministries and commissions' websites such as "Shenzhen government online", "Shenzhen Science and technology innovation Commission",

"Shenzhen Development and Reform Commission" and "Shenzhen Development and Reform Commission" and the authoritative database of Peking University. And the policies were searched and collected based on the principles as follows: the policies reflect the theme of innovation as much as possible, and the keywords are set as "high-tech industry", "independent innovation", "professional (Overseas) talents" and "enterprise technology (innovation)"; the policy documents mentioned the special schemes and special supporting policies involved in the innovation policy.

At the same time, in order to ensure the integrity of the data sources of policy texts, the government work reports and real-time news reports of major policies are tracked back to strengthen the comprehensiveness of the collection of policy texts. Through the collection and sorting of policy texts, after excluding invalid samples, 155 policy texts were obtained from 2011 to 2019. The policy classification is shown in Table 1.

TABLE 1 TYPES OF INNOVATION POLICIES IN SHENZHEN FROM 2011-2019

Policy type	Regulations	decision	Methods	Details	Planning
Quality	2	2	47	3	19
Policy type	Opinions	program	notification	measures	total
Quality	15	18	35	14	155

3.2 Measurement of Innovation Policy

1) Classification of Innovation Policy

Innovation activities are a complex, uncertain and risky process, which needs diverse and dynamically changing innovation policies, and the policy instruments are also diversified. Local governments choose different types of innovation policies and their mixes for different stages of regional innovation development. According to Zegvold and Rothwell (1981), enterprise innovation can be improved by three types of innovation policies, which includes demand-side policy (DSP), supply-side policy (SSP) and environmental-side policy (ESP). DSP refers to reducing market uncertainties of innovation, such as government procurement, trade control and R&D outsourcing. SSP indicates that the government's support for technological research and development through policy instruments, such as fiscal support, information support, innovation infrastructures, public services, human resources training. ESP refers to the governmental provision of a good institutional environment, such as taxation support, intellectual property protection, regulation, target planning and financial support.

In the all, the division of three types of innovation policies and 13 sub-categories of policy instrument is covered all policy measures to promote innovation used in Shenzhen. And it is critical to understand the influence of different policies on Shenzhen enterprises' innovation, which is helpful to understand the changes in promulgation, implementation and focus of Shenzhen innovation policy, so that Shenzhen government can master the development laws and trends of its regional innovation policies, and combine complementary policy instruments to promote enterprise innovation performance.

2) Scoring of Innovation Policy Instruments

According to the research of Peng Jisheng (2008) [12] and Zhong Weiguo (2009) [13], we measure Shenzhen innovation policies from four aspects: the policy issuing authorities, policy issuing outlook, policy instruments and policy issuing efforts.

In the policy issuing outlook dimension, all levels of Shenzhen governmental departments at the ministry level and above may issue various policy outlook, e.g., regulations, opinions, notifications, etc. Thus this paper mainly refer to existing research results of Peng Jisheng et al. (2008) for the specific scoring criteria of innovation policy issuing outlook and policy issuing efforts. And the scoring criterion of Shenzhen innovation policy outlook is as shown in Table 2.

TABLE 2 SHENZHEN INNOVATION POLICY OUTLOOK SCORING CRITERION

Score	Policy outlook
5	Laws promulgated by the Municipal People's Congress and its Standing Committee
4	Regulations and action plans for scientific and technological development promulgated by departments of the municipal (district) people's government
3	Provisional (trial) regulations, planning, opinions, plans, methods, management methods promulgated by the municipal (district) people's government
2	Interim regulations, opinions, methods, notification of application projects promulgated by municipal (district) departments
1	Temporary (trial) methods, interim opinions, notification promulgated by municipal (district) departments

In the policy instruments, based on the existing research of Rothwell and Zegweld (1981) [14], Peng Jisheng (2008) and Zhong Weiguo (2009), and based on various roles played by the Shenzhen government in enterprises' innovation, the innovation policies are divided into three categories and 13 sub-categories instruments. Actually, different policies differ in the intensity of text description, which often reflects the implementation intensity of the policy. Thus, Shenzhen innovation policy instruments are valued with 1-5 scores, and the higher the score is, the higher the policy effort. In order to ensure the reliability and consistency of the scoring of regional innovation policy instruments, the scoring criterion are referenced to existing research results (Peng Jisheng, 2008), and the scoring criterion is tested and revised by relevant experts. The final scoring criterion of sub-categories policy instruments is shown in Table 3.

TABLE 3 SUB-POLICIES CLASSIFICATION AND ASSIGNMENT CRITERIA

Score	Efforts description of sub-policies
	Government procurement
5	Emphasize government procurement from a legislative perspective
4	Expand the scope and scale of government procurement from more methods, including first purchase, order, first set of major technical equipment test (demonstration) projects, promotion and application, etc.
3	Strengthen the role of government procurement in the application and promotion of new technologies and products with expanding the catalogue of independent innovation products
2	Formulate government procurement policies and establish a government first purchase and ordering system
1	Only involve government procurement of public technology
	Trade control
5	Improve the service and guidance system of import and export from product catalogue established, and policy support of finance, tax, intellectual property etc.,
4	Vigorously support the free import and export of key equipment and technologies from the priority, expanded examination and approval, and simplify administrative procedures
3	Support import and trade from management of approval scope, simplified administrative procedures, established service guidance, specific products exempted from import tariff and import value-added tax
2	Government's attitude is permissible and give some policy support
1	Strict government control and designate the catalogue of prohibited or restricted import products
	R&D outsourcing
5	Vigorously support innovation, undertake major national innovation projects, provide comprehensive policy support and improve management
4	Support innovation organizations to undertake the research plan of regional industrial common technologies, and provide comprehensive policy support,
3	Support innovation organizations to undertake innovation plans for key industries in the region and provide comprehensive policy support,
2	Clearly encourage innovative organizations to undertake innovation plans, and provide corresponding policy support from one or more aspects of talent cultivation, finance, taxation and government subsidies
1	Only mentioned encouraging innovation organizations to undertake science and technology projects, without specific measures
	Fiscal support
5	Give maximum fiscal support from all links including diversified investment system, optimized capital structure, and combination of paid and unpaid, ex ante and ex post, competitive and stable, and inclusive support
4	Give great fiscal support from established diversified investment system, special innovation funds, and expanded support for innovation activities
3	Increase fiscal investment from more modes of financial investment, free subsidy, loan discount, phased allocation of project funds, and special fund for cooperation of industry and university with the investment no less than 100 million per year
2	Give certain fiscal support from special funds and priority investment for innovation

1	Only take subsidies and financial subsidies as the support
	Information support
5	Build a unified innovation information sharing platform; improve information sharing mechanism, unify data exchange standards and interfaces, and realize barrier free networking and sharing
4	Integrate all kinds of innovation resources and construct innovation infrastructure platform; strengthen the sharing of innovation resources and information
3	Strengthen the construction of various innovation resource library; form a thematic database or scientific data center network; reduce the restrictions on information sharing
2	Strengthen the construction of basic database including innovation resource, University expert, innovation achievements etc.; but share those databases only for specific enterprises, universities or local science and technology departments
1	Only mention to build various basic databases or information sharing
	Innovation infrastructures
5	Promote the integration of various innovation carriers and resources, based on management forms of council, joint-stock system, membership system and so on
4	Support universities, institutions and enterprises to jointly build various cooperative alliances of research, knowledge, industrial and standard; support the construction of international innovation cooperation
3	Support major innovation infrastructures with specific support rules, including major public innovation platforms, specialized common technology service platforms, high-tech industrial parks, independent innovation demonstration zones, emerging industry bases
2	Support various innovation carriers, engineering laboratories, experimental bases, R & D institutions, condition platforms and enterprise technology centers with specific policy rules
1	Only mentioned strengthening the construction of innovation infrastructure
	Public services
5	Improve various innovation intermediary service systems and the professional service standards whose service items become more professional, standard and network
4	Increase professional achievement transformation service institutions; improve the intermediary service level which is gradually in line with international standards
3	Establish more and more innovation intermediary service systems and improve the categories of innovation intermediary services
2	Support and increase all kinds of innovation intermediary service institutions; improve the service quality
1	Support a certain type of innovation intermediary service institutions of productivity promotion, technology transfer, technology brokerage institutions, etc.
	Human resource training
5	Improve the database of innovation talents and fully respect the flow of talents; encourage the reward according to post, task and performance, and improve the distribution of technological achievements, stock options, dividends and rewards; perfect social welfare and security system;
4	Improve the database of innovation talents and establish a joint talent cultivation base; respect the flow of talents and guarantee the innovative activities of talents; perfect social welfare and security system;
3	Establish a database of innovation talents and a joint talent cultivation base; increase the reward for talents with important achievements, which also is the indicators for assessment, promotion; encourage the flow of talents and perfect social welfare and security system;
2	Establish a dual tutor system and diversify training; set up a special fund for talents; provide convenient services for high-level talents studying abroad, such as Title Confirmation, special post allowance, legal income exchange and carrying or remitting abroad
1	Encourage talent flow and training, and introduce high-level talents studying abroad
	Taxation support
5	Stipulate a very low-income tax rate (no more than 10%), or pay enterprise income tax at the current tax rate by half, and exempt from tax for several years
4	Stipulate a lower income tax rate (no more than 15%) and reduce the tax by half or exempt from 1-2 kinds of taxes within several years
3	Stipulate a lower income tax rate (no more than 15%) only for enterprises with specific conditions, and exempt from 1-2 kinds of taxes
2	Stipulate a higher income tax rate (24%), and clear interest discount is the main measure without specified intensity and order
1	Only mentioned the supporting measure of tax discount without no specific measures; stipulate a fairly higher income tax rate (33% and above)
	intellectual property protection
5	Formulate local IP protection regulations; improve the IP service form the aspects of legislation, publicity, implementation and IP transaction;
4	Standardize the IP service market and cultivate the IP service industry; specify the protection of IP rights; improve IP ownership and benefit distribution mechanism of the combination of industry, University and research
3	Strengthen IP protection in various departments, develop IP information service platform and IP service institutions; strengthen market supervision
2	Clear support for IP protection from IP trading system, IP industrialization etc. with 1-2 support measures
1	Only involves IP protection and IP industrialization

5	Manage standardize innovation activities at the legal level; and establish systematic rules and regulations
4	Standardize the market and strengthen market supervision; manage, standardize and correct regulations of industry university research cooperation activities from specified methods
3	Standardize the market and strengthen market supervision; improve standardized management and regulations from more specific and detailed aspects
2	Clear standardized enterprise systems and industry standards, and specify management regulations from 1-2 aspects
1	Only mentioned the need to establish a standardized system and strengthen market supervision without more specific measures
	Target planning
5	More detailed implementation measures and time of target plan
4	More detailed implementation measures of target plan with a certain time range
3	Take innovation as the object with relatively specific measures
2	Take innovation as the object without relatively specific measure
1	only involves promoting scientific and technological innovation
	Financial support
5	Support innovation from all aspects including loans, financing channels, loan guarantees, services, with the strongest attitude, strength and scope
4	Support innovation from most aspects including loans, financing channels, loan guarantees, services etc., with relatively strong attitude strength and scope
3	Support innovation from some aspects including loans, financing channels, loan guarantees, services etc. with clear attitude strength and scope
2	Support innovation from 1-2 items of loans, financing channels, loan guarantees, services etc., with clear attitude strength and scope
1	Only mentioned financial support without detailed provisions or clear measures

3.3 Measurement of Policy Innovation Efforts

After analyzing the policy text of the Shenzhen innovation policy, the policy issuing outlook, policy instrument and policy issuing effort have been scored, and the preliminary data are obtained. The data will be further processed to meet the needs of analysis. This paper uses formula (1) to calculate the innovation policy efforts, using the formula (2) to calculate the overall efforts of the annual innovation policies.

$$P_{it} = \sum_{j=1}^{N} PS_{ij} \times PE_j \qquad t \in (2001,2019) \tag{1}$$

$$NP_t = \sum_{i=1}^{13} P_{it} \qquad t \in (2001,2019) \tag{2}$$

In the realistic of development in reginal innovation, public innovation policy is often effective for a period. When a innovation policy is abolished, the legal validity is lost. If a innovation policy has not been abolished and its impact on technological innovation will continue. Therefore, the overall efforts of the innovation policies in the current year should be accumulated by the efforts of the innovation policies issued in the current year and the efforts of that having not been abolished by the deadline. The formula is as follows:

$$NP_t = NP_{t-1} + P_{it} - \sum_{j=1}^{N^*} PS_{ij} \times PE_j \qquad t \in (2001,2019) \tag{3}$$

In the formula (1) to (3), t represents a particular year; j represents the policy j issued in the year t; N represents the number of innovation policies issued in year t; N^* represents the number of innovation policies abolished in year t; i represents the content in item i of policy j; P_{it} represents the efforts of item i in the t year; PS_{ij} represents score of content in item i of policy j; PE_j represents the efforts of the policy j; NP_t represents annual efforts of innovation policies in year t.

We argue that policy mix is a variety of different policy instruments. Thus, in order to better reflect the mixed effect of different policy instruments, and consistent with the single policy effort measurement method above, we measure the effort of DSP can be measured through the total efforts of government procurement, trade control and R&D outsourcing. The sum of efforts of support policy such as fiscal support, information support, innovation infrastructure, public services support and human resources training. The effort of ESP can be calculated through the total efforts of taxation support, intellectual property protection, regulation, target planning and financial support.

4 EMPIRICAL RESULTS

4.1 Comprehensive Policy

On the whole, Shenzhen's innovation policy system is relatively complete, and the promulgation of innovation policy has always been closing to the pulse of urban development. During 2011-2019, Shenzhen accelerated the supply of innovation policies. And based on the policy "Decision on accelerating the transformation of the mode of economic development" issued in 2011, Shenzhen promulgated a series of innovation policies, which covered multi-level sub fields from enterprise innovation support to the reform of innovation management mechanism, as well as the optimization of innovation environment. As a result, Shenzhen has formed a science and technology policy system with reasonable overall layout and clear functional positioning.

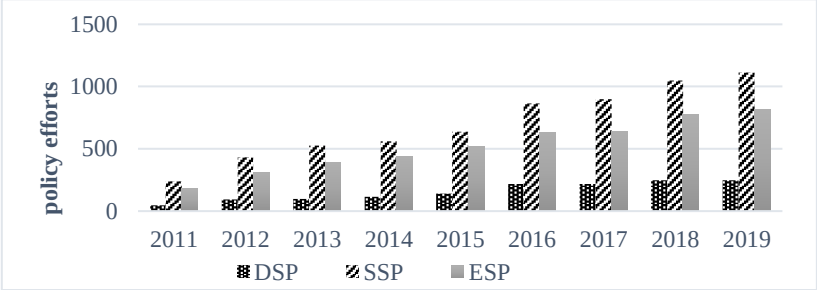

FIG.1 EFFORTS OF SHENZHEN INNOVATION POLICY INSTRUMENTS（2011-2019）

Furthermore, statistics show that supply-side policies played the main role in Shenzhen government issued innovation policies, environmental-side policies ranked second, and the last one is demand-side policies (as shown in Fig. 1). It can be seen that the policy system of Shenzhen focused on stimulating enterprise innovation through environmental-side and supply-side policies. In fact, in recent years, Shenzhen's innovation policy mainly focuses on intensive support: "intellectual property", "scientific and technological mechanism", "emerging industry system", "industrial innovation quality", "innovation ecology", "innovative talents", "innovation foundation and carrier", "industrial space" and other innovation elements. It can be seen that Shenzhen government focuses on increasing the supply of environmental and supply-side policies. It shows that the unbalanced in issued innovation policies of Shenzhen, which is similar to the unbalanced development of in Chinese national-level innovation policy system.

4.2 Demand-side Policy

Market orientation is the magic weapon of Shenzhen's high-tech industry development, and Shenzhen government has always followed this provision, whose issued policies mainly focus on the development of the market. Under this functional orientation, the promulgation and implementation of demand-side policies in Shenzhen is relatively weak. And Shenzhen government believed government procurement and R&D outsourcing are effective policy instruments that motivate enterprises to pursue innovation activities (as shown in Fig. 2).

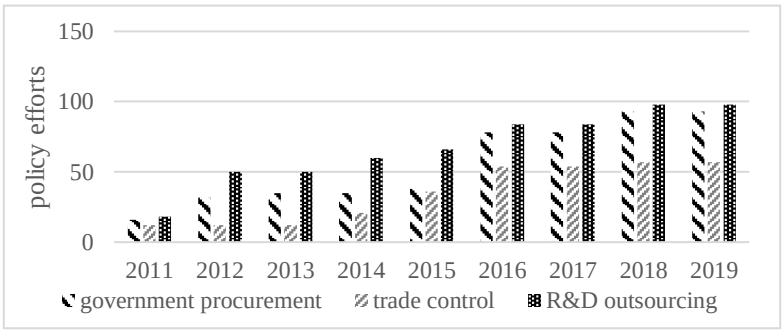

FIG. 2 EFFORTS OF DEMAND-SIDE POLICY

4.3 Supply-side Policy

Based on the issued policy of Regulations on accelerating the transformation of economic development mode in 2011,

Shenzhen made the planning of national innovation city. Then, Shenzhen promulgated series of innovation policy focused on how to fully implement innovation driven development. As a result, promulgation and implementation of supply-side policies were increased significantly, which especially focused on strengthening the supply of human resource training, innovation infrastructure and fiscal support (as shown in Fig. 3). And the economic and social benefits is remarkable: first, it has strong attraction to innovative talents. At present, the total number of various talents in Shenzhen exceeds 5 million, accounting for more than 40% of the city's permanent population. Secondly, the R & D investment of enterprises has been continuously increased. During 2020, R & D investment of Shenzhen accounted for 4.93% of GDP, higher than the national average level. Thirdly, innovation carriers are constantly emerging. In recent years, more than 2000 innovation carriers have been built in Shenzhen.

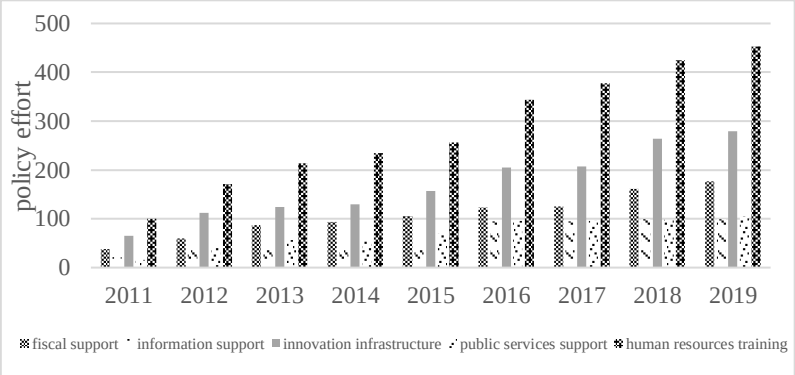

FIG. 3 EFFORTS OF SUPPLY-SIDE POLICY

4.4 Environmental-side Policy

Shenzhen government also attached great importance to the construction of innovation environment, and the main policy instruments including target planning, intellectual property protection and financial support (as shown in Fig. 4). obviously, the continuous optimization and clarity of the feasibility of policy objectives provided clear directional guidance for innovation. Then strengthening protection of intellectual property would form a sound business environment to motivate enthusiasm of R&D talents and, whose methods including developing the intellectual property market, promoting the transformation and implementation of patents and other intellectual property technologies. Meanwhile Shenzhen government also focused on the improvement of financial environment. As a result, Shenzhen developed into one of the most active cities in financial innovation, which has given a huge driving force for innovation of small, medium-sized and micro enterprises and start-ups.

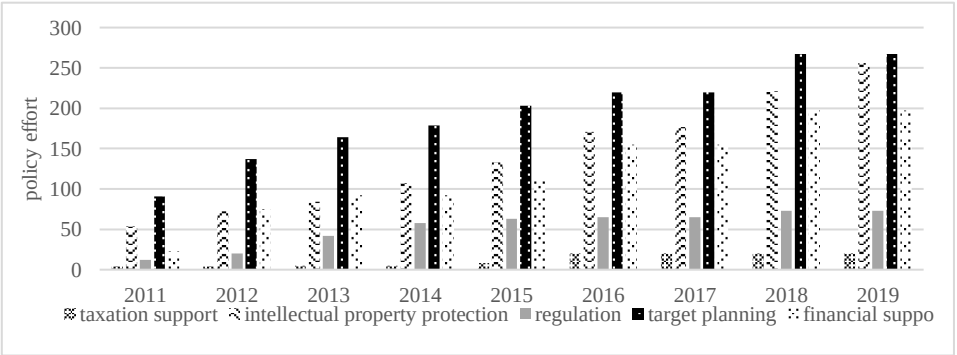

FIG. 4 EFFORTS OF ENVIRONMENT-SIDE POLICY

5 CONCLUSION

On the basis of systematically carding the quantization of 155 innovation policies issued by Shenzhen governmental departments from 2011 to 2019, this paper empirically analyzed the characteristics and deficiencies of Shenzhen innovation policy system from the perspective of different policy instruments and their mix. The principal results

mainly including: (1) The innovation policy instruments of Shenzhen have continuously enriched based on the different stage of development of innovation activities, especially during the period from 2011 to 2019. So far, Shenzhen formulated an innovation policy system with reasonable overall layout and clear function positioning, which provides a broad space for the independent innovation of enterprises. (2) There is a structural imbalance in Shenzhen's innovation policies. From the statistical analysis of the policy efforts in different types of Shenzhen innovation, supply-side policy was the most widely employed, followed by the environmental-side policy, and the least used policy type is demand-side policy, which indicates that Shenzhen government adopted unbalanced policy instruments to stimulate enterprise innovation. Another evidence is the uneven quantity of issued policy instrument, there are five items of supply-side policy instruments and environmental-side policy instruments respectively, which is much higher than supply-side policy instruments whose items is three, indicating that Shenzhen government excessively used supply-side policies and environmental-side policies and leading to the insufficient coordination between different policy instruments. (3) There are imbalances in the specific instruments in the supply-side policy, demand-side policy and environment-side policy. Specifically, two policy instruments of government procurement and R&D outsourcing were used most in demand-side policy, and three policy instruments of human resource training, innovation infrastructure and fiscal support were issued most in supply-side policy; while in the environmental-side policy, the most employed policy instruments including target planning, intellectual property protection and financial support. Actually, different policy instruments exert significantly different impact on innovation performance of enterprise, and the unbalanced issued policy instruments would lead to the poor application of some effective instruments, and cause negative incentives which induce enterprises to have too high dependence and expectation on the government and hurt the enthusiasm of enterprise independent innovation.

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