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Procedia Computer Science 266 (2025) 222–228

Procedia Computer Science

www.elsevier.com/locate/procedia

12th International Conference on Information Technology and Quantitative Management (ITQM 2025)

Multidimensional Deconstruction of Policy Tools: A Quantitative Assessment Framework Based on Frequency, Effectiveness, and Positional

Yingjie Sheng [a,b], Xiaolei Sun [a,b], Hubin Ma [a,b], Longfei Li [a,b]*

[a] Institutes of Science and Developmet, Chinese Academy of Sciences, Beijing, 100190, China

[b] School of Public Policy and Management, University of Chinese Academy of Sciences, Beijing, 100049, China

Abstract

Policy tools serve as the primary instruments through which governments achieve governance objectives, directly shaping the effectiveness and impact of public policy implementation. Existing studies lack a systematic, multidimensional analysis of policy tools, limiting the ability of single-dimensional studies to capture their complexity and diversity. To address this gap, this study proposes a policy tool attention index constructed through a three-dimensional analytical framework of frequency, effectiveness, and positional. This framework enables a quantitative assessment of the attention characteristics of policy tools across multiple dimensions. Findings reveal that supply-oriented and environmental policy tools dominate China's scientific and technological innovation policies, reflecting a governmental preference for fostering innovation through direct resource allocation and environmental optimization. In contrast, demand-oriented policy tools and international governance tools receive comparatively less attention. To enhance the overall efficacy of the innovation system, future policies should pursue a more balanced configuration of policy tools, emphasizing strengthened market demand-driven mechanisms and enhanced international cooperation.

Keywords: Policy tools; Policy attention; Frequency; Effectiveness; Positional

1. Introduction

Policy tools serve as the cornerstone instruments through which governments achieve their governance objectives, directly influencing the effectiveness and outcomes of public policy implementation. In confronting the practical

* Corresponding author. Tel.: +15628695648.
E-mail address: lilongfei22@mails.ucas.ac.cn (L.-F. Li).

1877-0509
10.1016/j.procs.2025.08.028

challenges posed by complex governance environments and diverse policy demands, the establishment of a multidimensional quantitative indicator system for policy effectiveness has emerged as an imperative requirement for accurately measuring policy attention and optimizing the allocation of governance resources. Existing research on policy tools has established a relatively comprehensive theoretical framework, with scholarly inquiries primarily advancing along three analytical dimensions. The ex-post evaluation perspective focuses on assessing the implementation effects of policy tools and their congruence with societal development trajectories [1]. The technical operation perspective systematically examines the lifecycle characteristics, implementation efficiency, and optimization pathways of policy instruments [2]. The stakeholder interaction perspective explores collaborative mechanisms among diverse stakeholders in the application of policy tools [3], thereby fostering a more holistic understanding of policy implementation dynamics.

While existing research on policy tools has provided valuable insights, there is still room for further development in terms of analytical frameworks. The systematic application of policy tools across different fields and administrative levels remains underexplored, limiting our understanding of the overall landscape and interconnections of policy instruments. Predominant research paradigms, such as tool typology analysis [4], stakeholder behaviour examination [3], and ex-post policy effectiveness evaluation [1], remain confined to sector-specific investigations or micro-level perspectives. These approaches have yet to yield a unified framework capable of systematically elucidating the frequency distribution patterns, effectiveness generation mechanisms, and positional evolution characteristics of policy tools. Moreover, much of the existing research continues to rely primarily on the macro-level "supply-demand-environment" framework for classifying policy tools [5]. This methodological orientation exhibits limited capacity for micro-level deconstruction of the internal structures of policy tools and fails to holistically integrate critical dimensions [6]. For example, some studies evaluate the significance of policy tools solely through occurrence frequency statistics, overlooking their hierarchical effectiveness and positional weight within policy documents [7]. Other prioritize stakeholder analysis without adequately considering the actual textual manifestations of policy tools [8]. Such unidimensional methodologies are inadequate for capturing the inherent complexity and diversity of policy tools, thereby constraining accurate assessments of policy attention allocation. These analytical gaps underscore the need for more sophisticated multidimensional frameworks in policy tool research.

To address these limitations, this study proposes a novel policy tool attention index grounded in a three-dimensional analytical framework of frequency, effectiveness, and positional, derived from the internal deconstruction of policy texts. This tripartite framework enables comprehensive and dynamic characterization of policy tool attention features, significantly enhancing the scientific rigor and multidimensionality of policy tool evaluation.

This study offers two primary contributions. First, it integrates frequency, effectiveness and positional dimensions into a unified analytical framework, enhancing the systematicity of policy text analysis and providing a novel decomposition strategy with finer granularity. Second, it develops an objective, quantitative methodology for assessing the multidimensional features of policy tools, reducing subjective bias in policy tool evaluation.

The remainder of this paper is organized as follows: Section 2 details the index construction framework and methodology. Section 3 presents empirical analysis results. Section 4 concludes with research findings, implications and summarizes the limitations of current research.

2. Construction of Policy Tool Index

2.1. Framework

To quantitatively evaluate the effectiveness and impact of micro-level strategies, this study constructs a policy tool attention index, as illustrated in Fig. 1. The index is developed through a structured methodology: extracting policy texts, designing quantitative dimensions, and measuring dimension indices.

The construction of the policy tool attention index begins by sourcing original policy documents from official government websites, ensuring the authority and accuracy of the data. Next, text extraction techniques are applied to identify and extract textual content from these documents, establishing a structured data foundation for subsequent analysis. Following the extraction process, an initial search is conducted using predefined keywords to identify paragraphs or statements related to policy tools, thereby narrowing the scope of analysis and improving efficiency.

Subsequently, policy tools are classified into four main types: supply-oriented, demand-oriented, environmental, and international governance tools. These categories are further divided into 22 subcategories. Definitions of the main dimensions and keywords associated with these policy tools are established. The keyword classification is developed based on policy element categorization and hierarchical coding, reflecting a comprehensive understanding of the different types of policy tools. To enhance the accuracy and breadth of keyword identification, the Word2Vec model is employed to conduct a semantic analysis of the policy texts. This approach allows for the expansion of the initial keyword list by incorporating synonyms and polysemous words, resulting in a more comprehensive vocabulary. Specifically, the Word2Vec framework utilized features a hidden layer consisting of 300 neurons, with each word represented as a 300-dimensional vector and a context window size of 6. To ensure the precision and comprehensiveness of policy tool identification, the classification dictionary is continuously refined by integrating additional professional terminology and adjusting semantic matching rules.

Finally, text analysis techniques are used to calculate the policy tool attention index, quantifying the emphasis policymakers place on various tools. This index provides robust data support for evaluating the effectiveness of policy tools and predicting future policy trends.

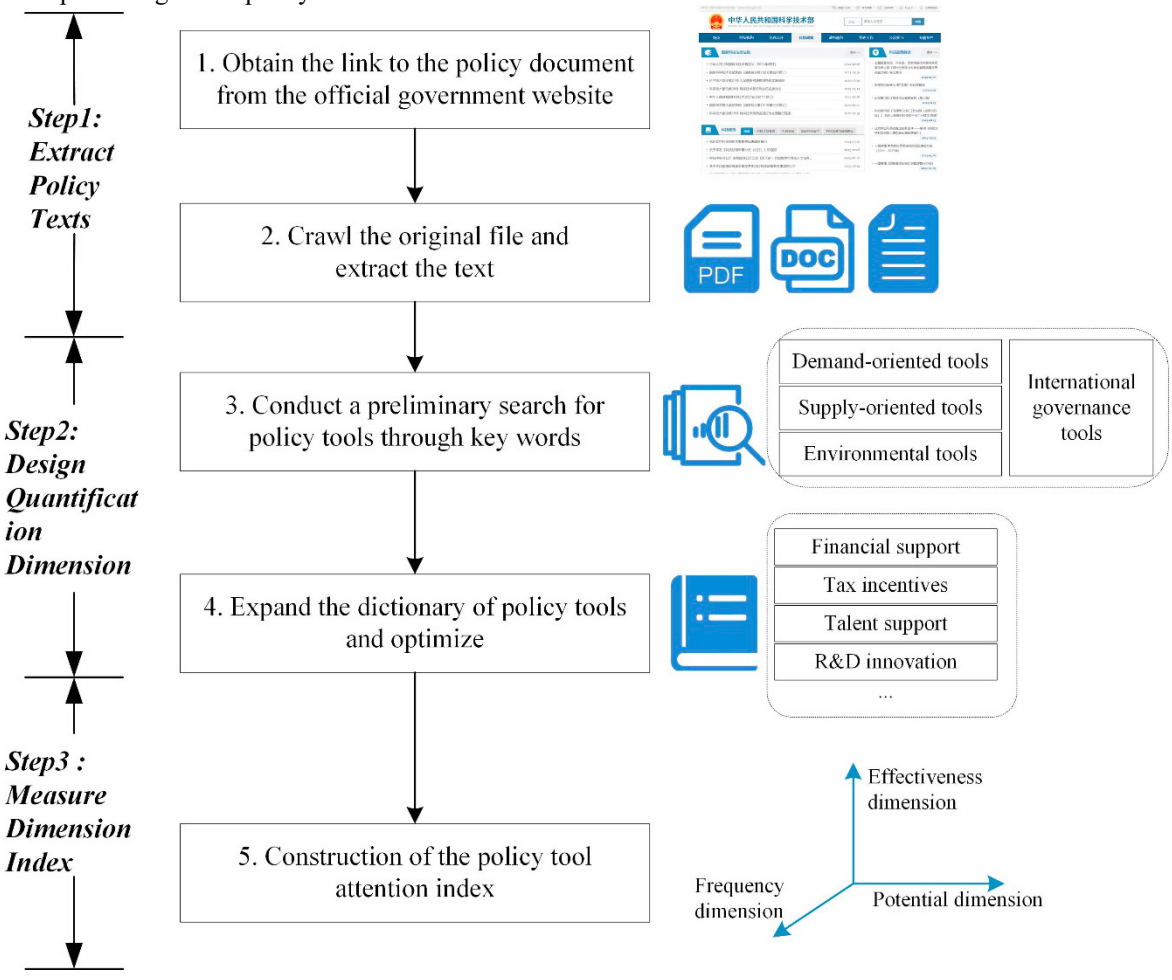

Fig. 1. Framework of the Construction Process for the Policy Tool Attention Index

2.2. Construction of the Policy Tool Attention Index

This study develops a three-dimensional analytical framework for the policy tool attention index, grounded in the hierarchical structure of how policy tools are prioritized and adopted within the policy system, encompassing

frequency, position, and effectiveness. The frequency dimension measures the occurrence rate of policy tools in policy documents to reflect their level of attention. The effectiveness dimension quantifies their influence by assessing the hierarchical authority of policy documents. The positional dimension evaluates their strategic priority by analyzing positional weights within policy text structures.

2.2.1 Frequency Dimension Index

First, the extracted keyword K_i is searched within the constructed policy text database to obtain the total number of occurrences f_i of the keyword.

Next, the number of policy documents q_i containing the keyword is counted.

Finally, the ratio of the total occurrences to the number of documents is calculated as the frequency dimension index, as shown in Formula (1):

$$Frequency\ Index(K_i) = \frac{f_i}{q_i} \tag{1}$$

2.2.2 Positional Dimension Index

The positional dimension analyzes the positional weight of keywords within policy texts to reveal the importance or priority of policy tools in policy documents. The appearance of keywords in prominent positions such as the file name or title typically signifies their core role in the document. By quantifying the relative importance of keywords through positional scores, it becomes possible to distinguish the hierarchical levels of policy tools within documents and uncover their strategic priorities across different levels of policy documents.

Positional weights are assigned based on the keyword's location within the text structure: 5 points for the file name, 4 points for a first-level heading, 3 points for a second-level heading, 2 points for a third-level heading, and 1 point for the main body. The positional information p_{ij} of keyword K_i in policy document D_j is obtained, where Ω represents the set of all policy texts within the analysis scope. Given the hierarchical structure of policy documents, keywords in more prominent positions convey stronger intent and attract greater attention. The maximum positional score for each keyword within a document is adopted as its positional information. The positional information across all documents is then aggregated to compute the positional dimension index, as shown in equation (2)

$$Position\ Index(K_i) = \sum_{j \in \Omega} Max\left\{scoring(p_{ij})\right\} \tag{2}.$$

2.2.3 Effectiveness Dimension Index

The effectiveness dimension focuses on the type of policy document to assess the positional influence and authority of different policy tools in policy implementation. Generally, policy tools associated with documents issued by higher-level institutions are considered to possess greater authority and enforcement power. Accordingly, as shown in equation (3), by assigning weighted scores to different document types, the effectiveness dimension quantifies the actual influence of policy tools across various levels of policy documents.

$$Efficacy\ Index(D_j) = b_m \times p_m \tag{3}$$

Drawing on the policy effectiveness quantification method proposed by Peng et al. [9]. The effectiveness dimension index is calculated by multiplying the type score p_m of the policy document by the number of issuing institutions b_m. This reflects the authority and influence of the policy document. Additionally, documents jointly issued by multiple institutions are deemed to have higher effectiveness due to their broader coordination scope. By assigning weighted scores to policy documents, this index provides an objective framework for evaluating the influence of policy tools.

As shown in Table 1, policy documents are categorized into five levels according to their issuance hierarchy and importance, ranging from the highest-level legal documents issued by the National People's Congress and its Standing Committee, as well as Five-Year Plans for National Economic and Social Development (scored 5 points), to lower-level notices, reports, and letters issued by ministries and commissions (scored 1 point). This forms a quantitative indicator system for policy strength.

Table 1. Quantitative Indicator System for Policy Strength

Policy Type	Indicator Score
Laws and documents issued by the National People's Congress and its Standing Committee, Five-Year Plans for National Economic and Social Development	5
Plans, programs, outlines, opinions, and schemes issued by the State Council	4
Plans, programs, opinions, schemes, and measures issued by various ministries and commissions, and measures issued by the State Council	3
Measures, guidelines, normative conditions, regulations, and standards issued by various ministries and commissions, and approvals, decisions, and reports issued by the State Council	2
Notices, reports, letters, and replies issued by various ministries and commissions	1

3. Case study

The study selected policies in the field of scientific and technological innovation for the extraction and analysis of the policy attention index. Using "science and technology" and "innovation" as keywords for the search, and based on the official websites of the State Council and the Ministry of Science and Technology, policies were retrieved according to whether they directly or indirectly promoted scientific and technological innovation. The retrieved policy texts were then screened to exclude irrelevant documents such as meeting notifications, event announcements, and project application notices. A total of 281 policy texts were obtained, including 219 national or ministerial-level planning and policy documents from 2011 to 2023, and 62 provincial-level "14th Five-Year Plan" and "14th Five-Year Science and Technology Innovation Plan" texts. The analysis results of the policy attention index for these policies are shown in Figure 2.

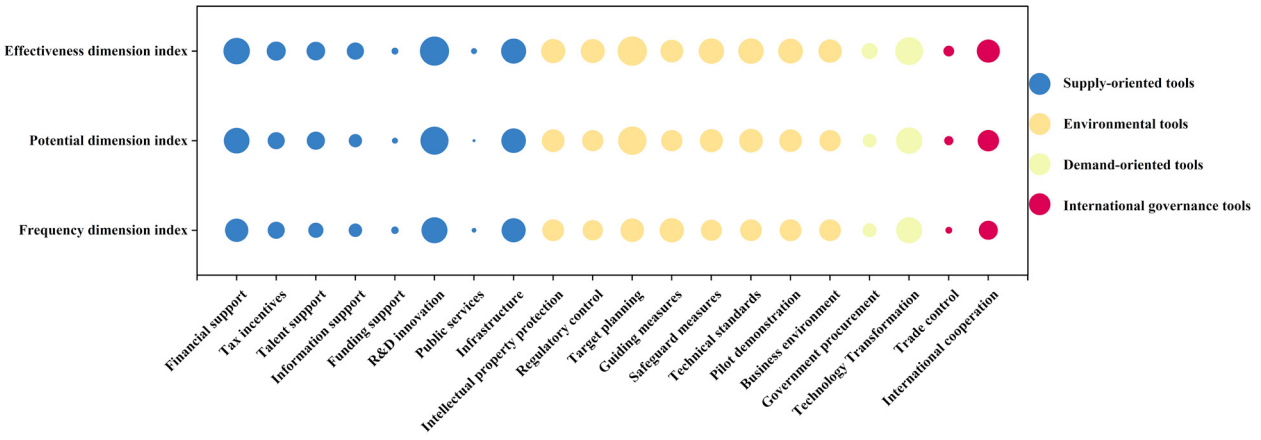

Fig. 2. Distribution of Policy Attention Indices for the Science and Technology Sector

From the perspective of frequency distribution, supply-oriented tools have the highest frequency index, followed by environmental tools, with demand-oriented tools ranking third. International governance tools have the lowest frequency index. The top five specific policy tools by frequency are technology transformation, financial support, technical standards, guiding measures, and infrastructure.

In terms of positional distribution, environmental tools exhibit the highest positional index, followed by supply-oriented tools, with demand-oriented tools ranking third. International governance tools again have the lowest positional index. The top five specific policy tools by positional are technology transformation, target planning, infrastructure, safeguard measures, and financial support.

Regarding effectiveness distribution, environmental tools show the highest effectiveness index, followed by supply-oriented tools, with demand-oriented tools ranking third. International governance tools remain the least

prominent. The top five specific policy tools by positional are technology transformation, target planning, infrastructure, safeguard measures, and financial support.

Overall, supply-oriented tools stand out in the frequency dimension, such as financial support and tax incentives, dominate the frequency dimension, indicating a governmental preference for direct resource inputs to drive scientific and technological innovation. Environmental policy tools, including regulations and target planning, score higher in the positional dimension due to their pivotal role in shaping long-term innovation ecosystems. Demand-oriented policy tools reflect the impact of market-driven policies but receive less attention compared to supply-oriented and environmental tools. International governance policy tools, such as international cooperation, exhibit relatively low overall attention but retain strategic importance.

Despite the critical role of demand-oriented and international governance tools in enhancing technological innovation systems, their attention within the current policy framework does not match their significance. This disparity likely stems from a traditional policy focus on supply-side interventions, which yield direct effects, whereas demand-oriented tools, such as government procurement and user incentives, operate indirectly. Additionally, international governance tools face challenges like cross-departmental and cross-national coordination, hindering short-term implementation and reducing their priority within core policy frameworks. This imbalance in the structure of policy tools undermines the synergy and sustainability of the innovation system. Over-reliance on supply-side inputs risks disconnecting innovation outcomes from market demand, impeding a virtuous innovation cycle. Similarly, neglecting international governance may confine technological innovation to internal circulation, limiting its ability to address complex global technological competition.

Consequently, China's science and technology policies primarily emphasize supply-side support (e.g., funding, tax incentives) and institutional environment optimization (e.g., regulations, safeguards). However, demand-side policies (e.g., government procurement) and international cooperation require further development. Future policy optimization should prioritize strengthening demand-side incentives and international collaboration to foster a more balanced and efficient innovation system.

4. Conclusions

This study achieves a multidimensional and systematic quantitative evaluation of policy tools by developing a three-dimensional policy tool attention index based on frequency, effectiveness, and positional. Methodologically, this study reduces subjective evaluation biases by employing objective quantitative indicators of policy tool attention indices, offering a replicable technical framework for the quantitative analysis of policy tool attention. Case analysis reveals that supply-oriented and environmental policy tools dominate China's science and technology innovation policies, reflecting a governmental preference for promoting innovation through direct resource inputs (e.g., financial support) and institutional optimization (e.g., regulatory frameworks). In contrast, demand-oriented policy tools (e.g., government procurement) and international governance tools receive comparatively less attention. These findings offer critical insights for policy optimization: future efforts should focus on balancing the structure of policy tools, strengthening market-driven incentives, and enhancing international cooperation to improve the overall efficiency of the innovation system.

This study focuses on science and technology innovation policy tools issued at the national ministry level, aiming to systematically analyze their structural characteristics and evolutionary trends. However, this sample selection inherently limits attention to local-level government policies, potentially reducing the applicability and representativeness of the findings at the regional level. Given the substantial variations in economic development, industrial structures, and innovation resource distribution across China's regions, local innovation policies exhibit significant diversity in content, objectives, and implementation pathways. Beyond this limitation, the study does not account for regional policy differences or dynamic temporal changes. Future research could address these gaps by expanding the data scope to include representative provincial or municipal policy texts, incorporating time-series analysis to examine the evolution of policy tools, and integrating additional semantic features to enhance classification accuracy. These improvements would foster a more comprehensive understanding of the synergistic mechanisms and distinct characteristics within the multilevel policy system.

Acknowledgements

This work was supported by the National Social Science Foundation of China (No. 23AZD071).

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