Artificial Intelligence (AI) methods empowering empirical research in public policy: a review of theoretical foundations and practices

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Abstract. Artificial Intelligence (AI) has become a key theoretical and practical focus in public policy, yet its specific applications and impacts in empirical public policy research still require in-depth exploration. Adopting a systematic literature review approach, this study collects recent literatures on the application of AI methods in empirical public policy research from the Web of Science Core Collection, as well as academic platforms such as CNKI and Wanfang Data. Through sorting and analyzing these literatures, this paper systematically combs the theoretical foundations of AI in the field of public policy and the practical applications of AI in empirical public policy research, aiming to reveal the current status of theoretical foundations and practical applications of AI methods in empirical public policy research.

Keywords: Artificial Intelligence, public policy, empirical research

1. Introduction

Against the backdrop of accelerated digital government construction, AI technology has become a core driving force for innovating government governance models and improving administrative efficiency. Since the 18th National Congress of the Communist Party of China, China has made a series of major arrangements for digital government construction. The 2024 Government Work Report further proposes the "AI+" initiative, clearly identifying AI as a digital infrastructure for empowering government services. The in-depth integration of AI and public policy research not only provides a data-driven and precise analysis tool for policy formulation, but also improves the efficiency of policy implementation and evaluation through intelligent algorithms, contributing to the construction of a law-based government and a service-oriented government. However, the current theoretical foundation of AI empowering public policy has not yet been systematized, and there remains a compatibility challenge between technological application and governance needs. Based on national strategic demands and combined with domestic and international practices, this paper systematically combs the theoretical framework, technical paths, and application scenarios of AI in empirical public policy research, aiming to provide academic support and practical guidance for the in-depth development of "AI + government services".

2. Theoretical foundations of Artificial Intelligence empowering public policy

2.1. Connotation of Artificial Intelligence

The proposal of Artificial Intelligence (AI) as a systematic disciplinary concept can be traced back to the 1956 Dartmouth Conference. Scholars such as John McCarthy conducted in-depth theoretical discussions around the core proposition of "machines simulating human cognitive mechanisms", thus laying the theoretical foundation and methodological framework for AI research. In terms of technological evolution, AI has undergone a transformation from the early formal representation and reasoning mechanisms based on mathematical logic to a composite technological paradigm led by deep learning. This paradigm has formed an interdisciplinary integrated technological architecture by integrating machine learning algorithms, big data analysis, and domain knowledge graph construction [1]. From the perspective of industrial economy, new AI technologies not only drive the optimization of production processes and innovation of product services in various links of the digital industrial chain, prompting the industrial ecosystem to show the characteristics of synergy and scale evolution, but also generate significant penetration effects and multiplier effects through the in-depth integration of intelligent technologies with the economy and society. Specifically, they promote the technological upgrading of related industries, stimulate the demand for new products and

services, and optimize the allocation efficiency of total factor productivity, thereby building a sustained innovation driving force for high-quality economic development [2]. Currently, with the continuous in-depth development of AI technology and the diversified expansion of application scenarios, the academic community has formed a multi-dimensional analytical framework for defining its concept, mainly from the macro, meso, and micro perspectives.

From a macro perspective, AI is regarded as the fourth-generation general-purpose technology (GPT) following steam, electricity, and information technology [3]. This technology not only possesses the techno-economic characteristics of information and communication technology (ICT) such as permeability, substitutability, and synergy, but also demonstrates innovative potential beyond the scope of traditional ICT, which can replace human creative activities [4]. Based on the above core technical characteristics, AI can significantly improve the transformation efficiency of input and output, realize the efficient allocation of factor resources, accelerate the iterative evolution of knowledge innovation, promote the synergy and in-depth coupling among various industries in the national economy, and provide solid technical empowerment and driving support for the sustainable growth of the national macro-economy.

From a meso perspective, AI constitutes a new generation of information technology integration system that integrates links such as data generation, collaborative R&D of software and hardware, and product application. This technology system can realize the optimal allocation of resources such as technology, capital, and talents within the intelligent industry, and create an intelligent operation ecosystem covering the entire industry [5]. Based on this, the intelligent industry can not only achieve leapfrog development with the help of AI, but also the industrial ecosystem it builds can gradually penetrate into all levels of the national economy, thereby strongly driving the economy towards a new height of high-quality development.

From a micro perspective, AI research focuses on the technology-organization adaptation mechanism at the enterprise level. On the one hand, through deep learning frameworks, AI can conduct multimodal integration of enterprise heterogeneous data resources [6], form a data-driven dynamic decision optimization system, and realize the refined management of production processes and the full-cycle control of operation links. On the other hand, the integration of AI technology promotes the enterprise operation system to show the characteristics of self-organization evolution, and builds an intelligent organizational structure with environmental perception and dynamic adaptation capabilities. This organizational resilience significantly enhances the ability of enterprises to gain competitive advantages in the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) environment. In this process, enterprises form a synergetic resonance effect of innovative factors through modular transformation paths such as digital twin of products and services, intelligent contract management of supply chains, and innovation of information value-added services. This effect follows the transmission logic of "core enterprises - industrial ecosystem - economic system", and forms a chain innovation network through technology spillover and knowledge diffusion, ultimately leading to the leap of structural parameters of the entire industrial economic system [7]. In addition, Xuan Yang and Zhang Wanli [8] proposed that the intelligent transformation of enterprises should be a comprehensive and systematic reform, covering multiple aspects such as technological innovation, production process optimization, organizational structure adjustment, and collaboration model innovation.

2.2. Public policy analysis theory

Public policy is a complex and multi-dimensional concept, and its definition varies significantly among scholars at home and abroad from different perspectives. Foreign scholars such as Thomas Dye and Harold Lasswell [9] mainly define public policy from the perspective of behavioral and management functions. They believe that public policy is not only a manifestation of government actions, but also a tool for guiding and adjusting social behaviors, emphasizing the importance of policies in achieving specific goals and values [10]. This perspective highlights the practicality and operability of policies, reflecting the emphasis on behavioral science in policy research in Western countries. In contrast, domestic scholars such as Zhang Jinma [11] pay more attention to the normative and guiding functions of policies. They argue that public policy is not only a guide for behaviors, but also a reflection of social values and ethical norms, emphasizing the importance of policies in promoting social progress and safeguarding public interests. Public policy refers to the behavioral norms or guidelines formulated by the government to solve public problems existing in society, aiming to effectively allocate and regulate social public interests and resources. As an important component of public policy, education policy embodies this basic characteristic. By formulating and implementing education policies, the government can optimize the allocation of educational resources, improve educational equity, and meet the social demand for high-quality education.

Policy analysis, as an applied research discipline, aims to provide practical solutions for policy organizations by reorganizing and integrating policy information. As Professor Chen Zhenming [12] pointed out, the core of policy science lies in in-depth analysis of the nature, causes, and consequences of public policies, thereby combining theory with practice, exploring the policy process and system, and striving to improve policy quality. Public policy analysis not only focuses on the process of policy formulation and implementation, but also emphasizes the selection of optimal solutions in complex policy environments to improve the effectiveness and feasibility of policy decisions. Through the combination of qualitative and quantitative research, policy analysis can achieve a more comprehensive understanding of policy influencing factors, evaluate policy effects, and thus provide a scientific basis for decision-makers [13]. The policy analysis framework proposed by Dunn [14] provides a systematic

closed-loop process for policy formulation, mainly including four stages: problem structuring, forecasting and analysis, decision-making, and monitoring and evaluation. In the initial stage of policy analysis, problem structuring is crucial, as it helps decision-makers clarify the core problems to be solved and provide directions for subsequent analysis. The forecasting and analysis stage uses data and models to predict the effects of policy implementation, providing a scientific basis for decision-making. In the decision-making stage, decision-makers make corresponding choices based on the previous analysis results to ensure the effectiveness and feasibility of policies. However, policy implementation is not the end; the monitoring and evaluation stage ensures that policies can achieve the expected goals during implementation through continuous monitoring and evaluation, and adjusts and optimizes policies in a timely manner. In this process, methods such as monitoring, forecasting, evaluation, suggestion, and problem structuring are interdependent, jointly forming a dynamic policy analysis system to ensure the effectiveness and flexibility of policies. Dunn's framework emphasizes the complexity and systematicness of policy analysis, providing important theoretical support and practical guidance for policy-makers.

3. Practical applications of Artificial Intelligence in empirical public policy research

3.1. Artificial Intelligence empowering public sectors

In public sectors, the rise of AI applications, especially the use of chatbots, has gradually triggered discussions on organizational innovation and transformation. Early studies pointed out that chatbots were mainly used to answer repetitive questions; although this application improved work efficiency, it failed to bring about fundamental organizational transformation. However, the latest research results put forward a more positive view, believing that by properly balancing the automation and augmentation functions of AI, chatbots have the potential to reshape organizational frameworks and promote the in-depth development of human-machine collaboration. This transformation can not only optimize service processes, but also create new organizational structures, making public sectors more flexible and efficient in responding to complex social demands. The views of researchers Noordt and Misuraca and Maragno et al. [15] indicate that the deepening and innovation of AI applications are not only technological progress, but also a re-examination and adjustment of organizational culture and structure. By effectively using chatbots, public sectors can better respond to citizens' needs while improving the efficiency of internal communication and collaboration, thereby achieving the sustainable development of organizations. Therefore, future research should continue to explore how to optimize the interaction between AI and human resources in practical applications to promote comprehensive innovation and transformation of public sectors. According to a study by Noordt and Misuraca [15], an analysis of 250 AI application cases in the European AI Inventory reveals the importance and functions of AI at three levels: policy formulation, public services, and internal management. These applications can not only identify problems, but also effectively improve the decision-making process, monitor policy implementation, promote public participation, and provide information and services. In addition, AI has also shown significant advantages in fields such as service discovery, talent recruitment, resource allocation, corruption detection, financial management, and asset maintenance. These functions enable governments and public sectors to operate more efficiently when facing complex challenges, improve service quality and transparency, thereby better meeting public needs and promoting social progress.

Although AI has shown positive potential in promoting organizational innovation, studies in the Netherlands, the United States, and Australia have shown that public sectors face many challenges in implementing AI technologies, which may lead to a series of adverse consequences. First, due to the lack of a systematic technological ecosystem and corresponding supporting measures, the application of AI in public sectors may lead to bureaucrat layoffs, thereby affecting the job stability and morale of employees [16]. In addition, the absence of supervision is also an important issue; the lack of transparency and accountability mechanisms in the decision-making process of AI systems may lead to a decline in public service quality and even trigger a trust crisis. More seriously, AI applications may generate socially disruptive systems, which do not consider social equity and ethics in the decision-making process, leading to decision-making errors in public sectors and thus causing long-term harm to society [17]. Therefore, when promoting the application of AI technology in public sectors, it is necessary to attach importance to establishing a sound technological ecosystem and formulating reasonable supporting measures to avoid potential negative impacts, ensure that the application of AI can truly serve public interests, and achieve the goal of organizational innovation. This phenomenon has triggered in-depth reflection on the future public management model, emphasizing the importance of balancing ethics and social responsibility in technological applications.

3.2. Artificial Intelligence empowering public policy

3.2.1. Improving decision-making efficiency

In recent years, the application of AI in the field of public policy has received increasing attention, especially its potential in improving decision-making efficiency has triggered extensive discussions. Roberts et al. [18] pointed out that the European

Union (EU) and the United States have similarities and differences in pursuing the goal of a "good AI society", emphasizing how to improve the efficiency and effectiveness of policy formulation by introducing AI technologies. AI can quickly process and analyze large amounts of data, helping decision-makers make more rapid and accurate judgments in complex social environments. At the same time, a study by Robinson [19] pointed out that the integration of cultural values is particularly important in the AI public policy strategies of Nordic countries, which not only promotes technological efficiency, but also enhances policy transparency and public trust, thereby forming a positive cycle. Sampath [20] discussed how to overcome social inequality in the governance of AI to ensure the fairness and efficiency of the decision-making process, emphasizing the normativeness and ethics of AI technology in policy design. Saveliev and Zhurenkov [21] explored the social responsibility reflected in the AI strategies of the United States, Russia, and China, indicating that countries should attach importance to social benefits while using AI technology to improve the efficiency of policy decision-making, so as to cope with complex challenges in the context of globalization. These literatures collectively depict an evolving public policy framework, showing the great potential of AI in improving decision-making efficiency, while also reminding us to pay attention to related ethical and social responsibilities.

3.2.2. Enhancing public participation

AI in public policy not only improves decision-making efficiency, but also shows important potential in enhancing public participation. Calboli and Engelen [22] explored AI-enhanced "nudging" strategies, believing that this method can optimize policy design and increase public understanding and acceptance of policies by analyzing public behavioral patterns, thereby promoting a higher level of participation. However, the implementation of this strategy is also accompanied by ethical and privacy concerns, reminding us to carefully set the boundaries of nudging to avoid unintended negative effects. In the process of enhancing public participation, van der Rooy [23] emphasized the importance of cognitive science, suggesting that policy-makers should design interaction methods based on human cognitive characteristics. This helps to ensure the effective participation of the public in policy discussions and improve the quality of policy responses. Hakimi et al. [24] studied the application of AI in the field of public health, pointing out that through AI technology, public opinions and feedback can be effectively collected, and policy issues in pharmaceutical practice can be improved, thereby making policies more in line with public needs. Cory [25] further emphasized the importance of cultural values in policies, believing that only by achieving trust, transparency, and openness can public participation in and support for AI policies be effectively enhanced.

3.2.3. Optimizing policy implementation and evaluation

The role of AI in optimizing the implementation and evaluation of public policies has become increasingly prominent, becoming the focus of the academic and practical circles. Vassilakopoulou et al. [26] studied the experience of the Norwegian government in developing human-AI interaction in customer services, pointing out that AI technology can improve service efficiency and user satisfaction, thereby optimizing the implementation effect of policies. This process not only relies on the advancement of technology, but also involves how policy-makers can effectively use these technologies to meet public needs. Waldman and Martin [27] explored the governance of algorithmic decision-making, emphasizing the importance of decision-making and its impact on the perceived legitimacy of algorithmic decisions. Their research shows that transparent algorithm governance can enhance public trust in policy implementation, thereby promoting the fairness and effectiveness of the policy evaluation process. Levin and Budak [28] explored the integration of AI and social media in the implementation of public health policies, believing that this integration can realize real-time monitoring of public health status and improve the timeliness and accuracy of policy evaluation. Li Jing and Yuan Yongtao [29] analyzed the reshaping of public communication by generative AI, and proposed that in policy evaluation, attention should be paid to the potential risks of AI technology and corresponding countermeasures. A study by Wei Yuming et al. [30] revealed the impact of AI innovation and development on the governance transformation of e-government, emphasizing the importance of digital technology in improving policy implementation and evaluation.

4. Conclusion

Currently, AI has become a hot research topic in the field of public policy. Its potential in improving decision-making efficiency, enhancing public participation, and optimizing policy implementation and evaluation is gradually changing the formulation and implementation models of public policy. In the future, with the continuous advancement of technology and the continuous expansion of application scenarios, the role of AI in the field of public policy will become more prominent. However, we should also clearly recognize that the application of AI technology is not a universal solution, and the challenges and risks it brings cannot be ignored. Therefore, in the process of promoting the in-depth integration of AI and public policy, we need to maintain a cautious attitude: while actively embracing technological innovation, we should properly address potential problems to achieve the sustainable development of the public policy field.

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