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New Quality Productivity and Latecomer Firms' Technological Catch-up: The Role of Dynamic Capabilities

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Abstract

New quality productivity results from revolutionary breakthroughs in technology, innovative allocation of factors of production, and in-depth transformation and upgrading of industries. The question of whether and how new quality productivity facilitates latecomer firms' technological catch-up has become an urgent research issue. This research uses a sample of A-share listed firms from 2011 to 2022 to examine new quality productivity's effect on latecomer firms' technological catch-up and investigate the underlying mechanism. The results show that the enhancement of new quality productivity significantly narrows the technology gap between latecomer firms and frontier firms, and empowers latecomers to achieve technological catch-up. The results remain robust after a series of tests, including those conducted via the propensity score matching method and the instrumental variables method, and an extended time window test. The mechanism test establishes that new quality productivity mainly promotes latecomer firms' technological catch-up by enhancing the three-dimensional dynamic capabilities: absorption capacity, innovation capacity, and adaptive capacity. Further analysis reveals that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where market/technological uncertainty, slack resources, and executive political relationships exist. These findings open the black box of how new quality productivity empowers the technological catch-up of latecomers from the perspective of dynamic capabilities, providing practical suggestions for latecomer firms to cultivate and develop new quality productivity and achieve technological catch-up.

Keywords

New quality productivity; Latecomer firms; Technological catch-up; Dynamic capabilities

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1. Introduction

Against the backdrop of the in-depth implementation of the innovation-driven development strategy, technological catch-up is not only a core path for latecomer firms to break through the "following-run" dilemma and move toward the high end of the value chain but also the key support for the country of the firms to achieve high-level technological self-reliance and promote high-quality economic development (Liu and He, 2024). As a dynamic process through which latecomer firms narrow the technological gap between them and the frontier firms or even surpass the latter (Lee and Lim, 2001), the driving mechanism of technological catch-up has long been a research focus in the field of innovation management. However, with the advent of the VUCA era—marked by the restructuring of international competition patterns, accelerated technological iteration, and volatile market demand—latecomer firms face dual-core challenges: on the one hand, traditional technological catch-up paths (e.g., imitative innovation, technology introduction) are constrained by technological barriers and path dependence, making it difficult to break free from "low-end lock-in" (Zhu and Li, 2025); on the other hand, the combination of external environmental uncertainty and internal resource constraints has led to the gradual diminishing marginal benefits of traditional driving factors such as R&D investment and policy support (Tarighi, 2024). In this context, exploring new driving forces for technological catch-up that can adapt to dynamic environments and break traditional bottlenecks has become an important proposition urgently requiring answers in theory and practice.

Existing studies have yielded rich results on the influencing factors of technological catch-up, focusing on dimensions such as organizational models (Ouyang and Zeng, 2021), resources and capabilities (Zheng and Guo, 2017; Peng and Yao, 2019), windows of opportunity (Wu *et al*., 2019; Peng and Zhu, 2022), and digital transformation (Zhang *et al*., 2022; Zhang *et al*., 2024; Ma *et al*., 2023; Ma *et al*., 2023). However, there are three significant limitations: First, insufficient attention has been paid to the cutting-edge theory of "new quality productivity." As an "advanced productive force state characterized by innovation as the leading role, breaking away from traditional growth paths, and featuring high technology, high efficiency, and high quality" (Xu *et al*., 2025), new quality productivity centers on breaking through traditional development models through the reconstruction of innovation factors and transformation of production functions. This highly aligns with the "path breakthrough" needs of latecomer firms for technological catch-up, yet existing studies have not systematically revealed the inherent link between new quality productivity and technological catch-up. Second, the analysis of the "black box mechanism" of technological catch-up is insufficient. Most existing studies focus on direct impact effects, while there is a lack of systematic exploration of the mediating paths (e.g., dynamic capabilities) through which new quality productivity acts on technological catch-up via capacity transformation. Third, the consideration of contextual heterogeneity is incomplete. How external environmental uncertainty and internal resource endowments moderate the enabling effect of new quality productivity has not been fully verified, making it difficult to guide differentiated practices for firms with different characteristics.

Since the concept of "new quality productivity" was proposed in 2023, this "important focal point" for promoting high-quality development has provided new insights into the ways to address the dilemma of technological catch-up among latecomer firms (Xu *et al*., 2025). The characteristics of "innovation-led" and "high-efficiency transformation" emphasized by new quality productivity may break traditional path dependence by enhancing firms' capacity to absorb external technological knowledge, achieve independent innovation breakthroughs, and dynamically adapt to the environment; meanwhile, their "high technology and high quality" attributes may enhance firms' technological competitiveness in uncertain environments. Based on this, the core research questions of this research focus on: Does new quality productivity enable technological catch-up in latecomer firms? If so, how? What are the manifestations of its mechanism of action (dynamic capabilities) and contextual heterogeneity (external environment and internal resources)?

To answer these questions, this study empirically examines the impact of new quality productivity on technological catch-up in latecomer firms and the underlying mechanism, using A-share listed companies from 2011 to 2022 as the sample. The results show that the improvement of new quality productivity significantly narrows the technological gap between latecomer firms and frontier firms, enabling latecomer firms to achieve technological catch-up. These conclusions remain valid after a series of robustness tests, including those using propensity score matching (PSM), the instrumental variable method, and time window extension. Mechanism tests reveal that new quality productivity ultimately promotes technological catch-up in latecomer firms primarily by enhancing three-dimensional dynamic capabilities: absorptive capacity, innovative capacity, and adaptive capacity. Further analysis reveals that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where market/technological uncertainty, slack resources, and executive political relationships exist.

The marginal contributions of this research are mainly reflected in three aspects: First, it is the first to systematically incorporate new quality productivity into the analytical framework of corporate technological catch-up, systematically analyzing the impact of new quality productivity on technological catch-up in latecomer firms and the underlying mechanism, and providing latecomer firms with new insights into technological catch-up from the perspective of new quality productivity. Second, it introduces dynamic capabilities as a mediating mechanism, building a logical bridge between new quality productivity and technological catch-up in latecomer firms through absorptive capacity, innovative capacity, and adaptive capacity, thereby profoundly unraveling the theoretical black box of how new quality productivity influences technological catch-up in latecomer firms. Third, from the perspectives of the external corporate environment (market environmental uncertainty and technological environmental uncertainty) and internal resources (slack resources and executive political relationships), it conducts an in-depth exploration into whether new quality productivity has heterogeneous impacts on technological catch-up in latecomer firms, providing theoretical reference and empirical evidence for listed companies with different governance characteristics to cultivate new quality productivity and achieve technological catch-up.

2. Literature Review

2.1. Research on new quality productivity

Building on classical economic theory, Marx was the first to deeply integrate the development of productive forces with scientific progress, putting forward the core viewpoint that "productive forces develop with the progress of science and technology." This theory has been extended in Chinese practice into the important proposition that "science and technology are the primary productive forces." With the deepening of the innovation-driven development strategy, the concept of "new quality productivity" has emerged (Ruanzhou and Guo, 2025). It is not only a concentrated embodiment of advanced productive forces but also an innovative development and practical application of Marxist theory of productive forces in contemporary China. Its core lies in achieving a systematic leap in total factor productivity through qualitative transformations in labor, means of labor, objects of labor, and their optimized combination. It is characterized by high technology, high efficiency, and high quality, and is highly aligned with the new development philosophy (Zhang and Chen, 2025). On January 31, 2024, General Secretary Xi Jinping stressed at the 11th collective study of the Political Bureau of the CPC Central Committee that "new quality productivity is an advanced state of productive force, where innovation plays a leading role, breaking away from traditional economic growth models and productive forces development paths, with characteristics of high technology, high efficiency, and high quality, and conforming to the new development philosophy (Xu *et al*., 2025; Shi and Jing, 2025)." This definition not only accurately summarizes the core attributes of new quality productivity but also provides theoretical guidance for latecomer firms to break through technological barriers and achieve catch-up—new quality productivity is thus positioned as the underlying support for latecomer firms' technological catch-up.

Existing research mainly focuses on theoretical connotations, generation logic, and measurement. (1) From the perspective of the theoretical connotation of new quality productivity, the mainstream view holds that new quality productivity emerges from achieving key disruptive technological breakthroughs (Zhou and Xu, 2023) and is a productive force with the basic connotation of a leap in labor, means of labor, objects of labor, and their optimized combination (Liu, 2024). (2) From the perspective of the generation logic of new quality productivity, existing literature suggests that new quality productivity is composed of "high-quality" laborers, "new-medium" means of labor, and "new-material" objects of labor (Xu, 2024) and is an advanced productive force state spawned by revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth industrial transformation and upgrading (Huang and Sheng, 2024). (3) From the perspective of the measurement of new quality productivity, existing studies have mainly constructed indicator systems based on the three-factor or two-factor theory of productive forces to measure the development of new quality productivity at the provincial level in China (Liu and He, 2024; Xu *et al*., 2025; Wang and Chen, 2025; Zhang *et al*., 2024) and at the firm level (Xu, 2024; Yue *et al*., 2024; Song *et al*., 2024). In addition, Han *et al*. (2024) innovatively divided the constituent elements of productive forces into two categories: substantive elements and permeating elements. Substantive elements mainly include laborers, means of labor, and objects of labor, while permeating elements mainly include new technologies, production organization, and data elements, and based on this, they constructed a measurement indicator system for provincial new quality productivity. Yu and Zhang (2024) constructed and measured new quality productivity in European countries from the perspective of digital and green synergy, providing a reference for cross-regional comparative studies.

However, existing research still has significant gaps: although in-depth analysis has been conducted on the theoretical connotation, generation logic, and measurement methods of new quality productivity, the mechanism of action of new quality productivity as a key element in the technological catch-up of latecomer firms has not yet been systematically explored. In fact, the "high technology" characteristic of new quality productivity (such as disruptive technological breakthroughs) can provide latecomer firms with a "window of opportunity" for technological leapfrogging, and the "high efficiency" characteristic (such as optimization of factor allocation) can reduce the costs of technological transformation for latecomer firms. Both have inherent coupling with the core needs of latecomer firms for "technological catch-up and path breakthrough". Therefore, clarifying the relationship between new quality productivity and the technological catch-up of latecomer firms is not only key to filling the theoretical gap, but also of significant guiding significance for practice.

2.2. Research on latecomer firms' technological catch-up

The term "latecomer firms" refers to imitators and rapid learners that lack resources in the early stage of entering an industry, hence aim to catch up through latecomer advantages, and face technological disadvantages like being far from core technologies and market disadvantages like being distant from mainstream markets (Hobday, 1995; Mathews, 2002). The term "technological catch-up of latecomer firms" refers to the process of activities that remedy disadvantages and increase added value by improving market capabilities and technological capabilities. This process is not only a simple imitation of new technologies but also a process of surpassing forerunners through breakthrough innovation (Miller *et al*., 2009; Zhou *et al*., 2023). Based on this, how latecomer firms achieve technological catch-up has become a focal issue of relevant research.

The existing literature has explored the factors promoting latecomer firms' technological catch-up from different perspectives. First, the organizational model. Ouyang and Zeng (2021) found that technological catch-up of latecomer firms is a complex systems engineering, and exploring an innovative organizational model suitable for themselves is a key factor in promoting technological catch-up. Second, resources and capabilities. Dynamic capabilities are regarded as a key driving factor. Studies by Zheng and Guo (2017) and Peng and Yao (2019) show that dynamic capabilities can enhance latecomer firms' sensitivity in identifying windows of opportunity and drive them to achieve technological catch-up by coordinately integrating internal and external knowledge and resources. In addition, Shou *et al*. (2018) and Hu *et al*. (2023) found that by joining technical standard alliances, latecomer firms can break through the constraints of technology, knowledge, capital, and innovation resources, improve their market position, and lay a practical foundation for technological catch-up. At the level of international cooperation, Giuliani *et al*. (2016) analyzed cross-border inventions between enterprises from Brazil, India, and China and EU inventors during the period from 1990 to 2012, and pointed out that such inventions provide opportunities for enterprises in emerging countries to accumulate technological capabilities, acquire cutting-edge knowledge, and secure the property rights of co-inventions. Third, window of opportunity. The window of opportunity is considered an important opportunity for latecomer catch-up. Wu *et al*. (2019) found that in the two stages of latecomer firms' "catch-up and post-catch-up," the dynamic matching of technological window of opportunity, demand window of opportunity, and institutional window of opportunity with enterprise innovation strategies can effectively improve catch-up performance. Peng and Zhu (2022) further pointed out that when the uncertainty of the window of opportunity is high, latecomer firms can overcome dual market and technological disadvantages by building market-oriented and technology-oriented alliance portfolios. Fourth, digitalization. The driving role of digital transformation in technological catch-up has also attracted attention. Existing studies show that digital transformation has multidimensional impacts on latecomer firms' capacity building, realization of disruptive innovation, and catch-up effect, and is a key driving force for promoting latecomer firms to move towards technological leadership and frontier (Zhang *et al*., 2022; Zhang *et al*., 2024; Ma *et al*., 2023).

After reviewing existing studies, we find that relevant literature on latecomer firms' technological catch-up mostly focuses on the interpretation of theoretical connotations and summary of case experiences. However, there is still a lack of systematic quantitative analysis and empirical testing on the impact of new quality productivity on latecomer firms' technological catch-up. For this reason, this research empirically examines the impact and mechanism of action of new quality productivity on latecomer firms' technological catch-up from the perspective of dynamic capabilities. This not only expands the theoretical boundary of the drivers of latecomer firms' technological catch-up but also provides important theoretical guidance for latecomer firms to cultivate and develop new quality productivity and achieve technological catch-up.

3. Research Hypotheses

3.1. New quality productivity and latecomer firms' technological catch-up

First, new quality productivity accumulates original momentum for latecomer enterprises' technological catch-up by improving the quality of production factors and cultivating high-end production factors. New quality productivity drives the transition of production factors from "low-quality homogeneity" to "high-end heterogeneity" (Liu and He, 2024; Zhang and Chen, 2025), which is specifically reflected in three dimensions: At the laborer level, new quality productivity promotes the transformation of laborers from "physical/experience-intensive" to "knowledge/skill-intensive" through tools such as AI-assisted decision-making and digital skills training, directly improving the quality of human capital. At the level of means of labor, new quality productivity drives the integrated evolution of traditional tools toward the integration of "intelligent equipment + digital platforms," enabling latecomer enterprises to skip the linear path of "mechanization → automation → intelligence" in traditional industrialization, directly enter the intelligent production stage, and quickly narrow the equipment and technological gap with first-mover enterprises (Sun and Li, 2024). At the level of objects of labor, new quality productivity forms a "data + entity" dual-driver model through the integration of data with traditional physical factors (Chu *et al*., 2025). Latecomer enterprises can rely on the industrial internet to collect full-chain production data, build process optimization models, break through the technological patent barriers of first-mover enterprises, and form differentiated technological advantages.

Second, new quality productivity provides efficiency support for latecomer enterprises' technological catch-up by optimizing factor allocation efficiency and stimulating enterprises' innovation momentum. In the cultivation of new quality productivity, it is accompanied by the efficient aggregation of innovation factors and the expansion of new tracks (Wang and Chen, 2025; Zhang *et al*., 2024), helping latecomer enterprises break away from traditional growth models and transform from a pattern relying on low-cost advantages to a new one leveraging innovation advantages. On the one hand, new quality productivity can rely on digital innovation networks such as remote R&D platforms and online technology markets to break information asymmetry and geographical restrictions, achieving the borderless flow and efficient matching of innovation factors such as talent, technology, and data. On the other hand, new quality productivity can promote the in-depth coupling of "talent–capital–data–technology," achieving "targeted innovation," including reduction in innovation risks via digital finance, accurate matching with market demands with aid of big data, and optimized resource allocation by way of AI algorithms (Ma *et al*., 2025). In addition, in new tracks spawned by new technological revolutions such as AI and quantum computing, new quality productivity can also take advantage of the window period when technical standards are not yet finalized, seize technological first-mover advantages through rapid iteration models such as agile development and user co-creation (Chu *et al*., 2025), and avoid patent blocking in traditional tracks.

Finally, with independent innovation as the core driving force, new quality productivity promotes latecomer enterprises to achieve technological catch-up by enhancing their competitiveness in the industrial chain and value chain. New-quality productive forces drive latecomer enterprises to shift from "technological imitation" to "original innovation leadership", with specific manifestations as follows. (1) Transformation of R&D models. New quality productivity promotes the shift of R&D toward "data-driven + scenario innovation," enabling latecomer enterprises to gradually gain the initiative in technological innovation through industrial big data analysis to predict technological evolution trends and verification in real scenarios to accelerate the implementation of original technologies (Xu *et al*., 2024). (2) Value chain upgrading. New quality productivity enhances the technological content of products through independent innovation, promoting enterprises to extend to high-end segments of the value chain (such as core components and technical services), expanding profit margins to feed back R&D investment, and forming a positive cycle of "innovation–profit–re-innovation." (3) Construction of open innovation organizations. New quality productivity promotes enterprises to establish "agile R&D teams + industry-university-research collaboration networks," stimulating R&D creativity through flat management internally and integrating basic research resources by collaborating with universities and research institutions externally, realizing a leap in innovation capability from "single-point breakthrough" to "systematic improvement" (Yue *et al*., 2024; Han *et al*., 2024). Based on this, this research proposes the following research hypothesis:

H1. New quality productivity can promote technological catch-up of latecomer enterprises.

3.2. Mediating role of dynamic capabilities

The core logic of new quality productivity empowering latecomer enterprises' technological catching-up lies in relying on dynamic capabilities as an intermediary bridge. From the perspectives of the resource-based view, dynamic capability theory, and latecomer advantage theory, technological catching-up is essentially a dynamic transformation process of "resource–capability–performance." New quality productivity drives the synergistic improvement of the three dimensions of dynamic capabilities (absorptive capacity, innovative capability, and adaptive capability) by reshaping the quality and allocation efficiency of resource factors (Wang and Ahmed, 2007), thereby breaking technological lock-in and shortening the catching-up cycle.

Dynamic capability theory (Teece *et al*., 1997) points out that enterprises need to respond to hyper-competitive environments by integrating, building and reconstructing resources and capabilities. Meanwhile, new quality productivity—defined as a productivity form "with technological innovation at its core and characterized by digitalization/intelligence"—has undergone qualitative leaps and allocation revolutions in traditional production factors (labor, capital, technology), which precisely provide the underlying driving force for improving dynamic capabilities. The latecomer advantage theory further emphasizes that the "corner overtaking" of latecomer enterprises relies on external knowledge absorption, integration of innovative resources, and the ability to adapt to technological trends—that is, the core functions of dynamic capabilities (Tarighi, 2024). Therefore, the enabling effect of new quality productivity on technological catching-up needs to be realized through the mediating role of dynamic capabilities: absorptive capacity breaks knowledge barriers, innovative capability breaks through technological bottlenecks, and adaptive capability avoids path dependence, ultimately forming a transmission chain of "new quality productivity → dynamic capabilities → technological catching-up."

First, new quality productivity empowers latecomer enterprises' technological catching-up by enhancing their absorptive capacity. Absorptive capacity is the core capability for latecomer enterprises to break through the "cognitive barriers" of technological catching-up, and its essence is a dynamic process of "identifying-absorbing-integrating-applying" external knowledge (Gala-Velásquez *et al*., 2025). New quality productivity systematically improves the knowledge conversion efficiency of absorptive capacity through digital tools and collaborative models, laying a cognitive foundation for technological catching-up. Specifically, in the knowledge identification stage, digital tools in new quality productivity can help latecomer enterprises scan global technological frontiers in real time, screen high-value knowledge through intelligent algorithms (Dong *et al*., 2024), reduce identification bias caused by "information overload," and accurately locate catchable technological targets. Based on the knowledge-based view, knowledge integration is a prerequisite for innovation (Fabrizio *et al*., 2022). In the knowledge integration stage, the digital collaboration model promoted by new quality productivity breaks down traditional inter-departmental knowledge barriers, accelerates the integration of external and internal knowledge systems through knowledge rights confirmation, traceability mechanisms, and simulation of knowledge application scenarios, forming structured knowledge reserves. The ultimate goal of absorptive capacity is to transform knowledge into technological innovation. In the knowledge application stage, intelligent production tools in new quality productivity can directly embed absorbed cutting-edge knowledge into production processes, shorten the knowledge conversion cycle through "learning by doing", and form a positive cycle of "absorption–application–re-absorption," accelerating the technological catching-up process.

Second, new quality productivity empowers latecomer enterprises' technological catching-up by enhancing their innovative capability. Innovative capability is the core driving force for latecomer enterprises to achieve the transition from catching-up to surpassing (Ruiz-Ortega *et al*., 2024), and new quality productivity promotes the leap of innovative capability from "imitative innovation" to "independent innovation" by reconstructing innovative elements and models. First, according to innovation system theory, innovative capability depends on the "quality" rather than "quantity" of factor input (Ji *et al*., 2025). New quality productivity systematically optimizes the quality of innovative elements by improving the innovation efficiency of technological elements, optimizing the allocation precision of capital elements, and enhancing the skill levels of human elements, providing basic support for technological breakthroughs (Ren *et al*., 2024). Second, new quality productivity promotes the transformation of innovation models from "linear innovation" (R&D → production → sales) to "ecological innovation," which reduces innovation risks by integrating R&D resources upstream and downstream of the industrial chain, shortens technological gaps through collective intelligence, and realizes corner overtaking. Third, based on resource dependence theory, enterprises need to rely on external market feedback to adjust innovation directions. New quality productivity captures market demand through real-time data feedback mechanisms, avoids innovation islands, improves the success rate of commercialization, accumulates innovative resources, feeds back into subsequent R&D, and forms a virtuous cycle of "innovation–benefit–re-innovation."

Finally, new quality productivity empowers latecomer enterprises' technological catching-up by enhancing their adaptive capability. Latecomer enterprises face greater environmental uncertainty in technological catching-up, and adaptive capability is the key for them to avoid risks and seize opportunities. New quality productivity enhances adaptive capability through the following mechanisms: First, it enables intelligent upgrading of environmental perception. Compared with traditional productivity, the intelligent perception systems of new quality productivity can capture external environmental signals in real time (such as policy orientations, technological breakthroughs, and competitor dynamics) (Abou-Foul *et al*., 2023). Based on contingency theory, enterprises need to adjust strategies to match environmental changes. New quality productivity provides a basis for latecomer enterprises to identify emerging technological opportunities or potential risks in advance through environmental signal trend deduction models, supporting technological catching-up decision-making (Chen *et al.*, 2025; Liu *et al.*, 2025). Second, it enhances flexibility in resource restructuring. The core of adaptive capability is to rapidly adjust resource allocation (Wang and Ahmed, 2007). The flexible production systems in new quality productivity enable enterprises to quickly switch production directions during technological iterations, avoid technological lock-in caused by sunk costs, and maintain dynamic tracking of technological frontiers. Third, it deepens agility in organizational learning. The essence of adaptive capability is organizational learning capability (Felsberger *et al.*, 2022). New quality productivity promotes the shift of organizational learning from an experience-driven mode to a data-driven mode. By analyzing employee behavior data to identify learning bottlenecks, sharing technology response experiences, and delivering personalized learning content, it accelerates the adjustment of enterprises' own technological routes and maintains the catching-up pace in dynamic environments.

In conclusion, new quality productivity improves the knowledge conversion efficiency of absorptive capacity through digital tools, strengthens the technological breakthrough momentum of innovative capability through the reconstruction of innovative elements and models, and enhances the environmental matching accuracy of adaptive capability through intelligent perception and flexible allocation. The synergistic effect of the three constitutes the capability triangle for latecomer enterprises' technological catching-up: absorptive capacity solves knowledge acquisition challenges, innovative capability breaks through the constraints of technological barriers, and adaptive capability reduces the risks of environmental uncertainty. Accordingly, this research proposes the following research hypothesis:

H2. New quality productivity promotes latecomer enterprises' technological catching-up by enhancing their three-dimensional dynamic capabilities, namely absorptive capacity, innovative capability, and adaptive capability.

The theoretical model of this research is shown as follows:

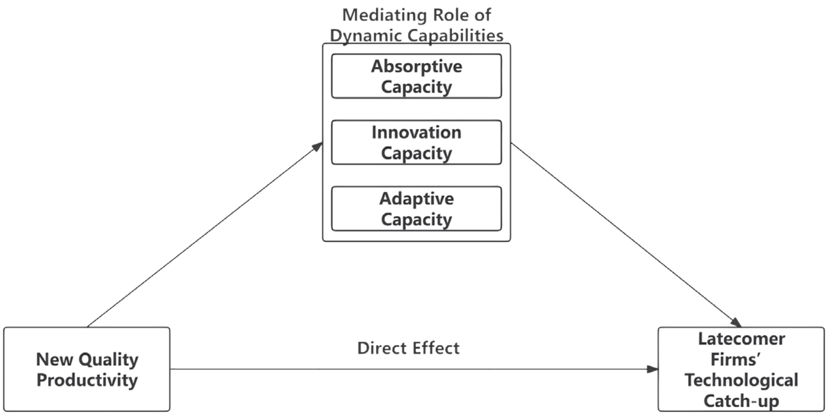

Fig. 1. Theoretical model diagram.

4. Methodology

4.1. Sample selection and data sources

This research selects A-share listed companies from 2011 to 2022 as the sample. After removing the listed companies in the financial and insurance industry, ST or *st companies and the sample companies with serious data deficiencies, we finally obtained the unbalanced panel data of 3,739 listed companies, a total of 21,090 companies' annual observations. In order to eliminate the influence of extreme values, we winsorized the continuous variables at the 1% and 99% quantiles. Among them, enterprise patent data is from CNRDS database, and other financial data is from CSMAR database.

4.2. Variable measurement

4.2.1. Technological catch-up (Gap)

Either at the national, industry, or enterprise level, it is difficult to directly measure the effect of technology catch-up. The existing literature mainly indirectly measures the effect of technology catch-up by observing the changes in the technology gap between latecomers and leading-edge enterprises (Ma *et al*., 2023; Ma *et al*., 2023; Zhang *et al*., 2023; Hu *et al*., 2023). Therefore, we use the total factor productivity gap between catch-up enterprises and leading-edge enterprises to measure technological catch-up (Ma *et al*., 2023; Ma *et al*., 2023; Qing, 2021). The specific calculation formula is as follows:

$$Gap_{ijt} = \frac{TFP_{jt}^{99}}{TFP_{ijt}} \tag{1}$$

In equation (1), TFP_{jt}^{99} is the 99th percentile enterprise total factor productivity of industry j to which enterprise i belongs in year t. TFP_{ijt} is the actual total factor productivity of enterprise i in industry j in year t. The smaller the Gap_{ijt} value, the smaller the technological frontier gap between enterprise i and its industry j. In addition, we use the LP method to measure the total factor productivity of enterprises.

4.2.2. New quality productivity (Nqpf)

Referring to the research methods of Yue *et al*. (2024) and Song *et al*. (2024), based on the theory of two factors of productivity, considering the role and value of labor objects in the production process, we build a new quality productivity index system from the two levels of workers and labor tools (consisting of 4 secondary dimensions and 11 tertiary indicators), and use the entropy method to calculate the new quality productivity of enterprises.

Table 1
New quality productivity index system.

Factors	Sub factors	Indicators	Measure	Weight
Labour force	Living labor	Salary ratio of R & D employees	R & D employee salary / operating income	28
		Proportion of R & D employees	R & D staff / total staff	4
		Proportion of highly educated employees	Number of employees with bachelor degree or above / total employees	3
	Materialized labor	Proportion of fixed assets	Fixed assets / total assets	2
		Proportion of manufacturing expenses	(Amortization of intangible assets + depreciation of fixed assets + cash outflow from operating activities + impairment provision – employee salary and compensation – cash for commodity purchase and receiving services) / (amortization of intangible assets + depreciation of fixed assets + cash outflow from operating activities + impairment provision)	1

Table 1. (continued)

Factors	Sub factors	Indicators	Measure	Weight
Tools of labor	Soft technology	Portion of R & D depreciation and amortization	R & D depreciation and amortization / operating income	27
		Proportion of R & D rental fee	R & D lease expense / operating revenue	2
		Proportion of direct R & D investment	R & D direct investment / operating income	28
		Proportion of intangible assets	Intangible assets / total assets	3
	Hard technology	Turnover of total capital	Operating income / total assets	1
		The reciprocal of the equity multiplier	Owners' equity / Total assets	1
New quality productivity				100

4.2.3. Dynamic capabilities

Firstly, absorptive capacity (Absorb) is measured by the intensity of R&D expenditure, that is, the proportion of R&D expenditure in operating revenue.

$$Absorb = \frac{R\&D\ expenditure}{operating\ revenue} \tag{2}$$

Secondly, innovation capacity (Innovation) is measured by the sum of the standardized R&D expenditure intensity and the proportion of technical personnel.

$$Innovation = \frac{(X_{\text{R \& D intensity}} - \min_{\text{R \& D intensity}})}{(\max X_{\text{R \& D intensity}} - \min_{\text{R \& D intensity}})} + \frac{(X_{\text{technical personnel ratio}} - \min_{\text{technical personnel ratio}})}{(\max X_{\text{technical personnel ratio}} - \min_{\text{technical personnel ratio}})} \tag{3}$$

In equation (3), technical personnel ratio = number of technicians/total number of employees.

Thirdly, adaptive capacity (Adapt) is measured by the coefficient of variation of R&D expenditure intensity, capital expenditure intensity, and sales expenditure intensity. In addition, in order to make the variation coefficient value consistent with the direction of adaptability, the variation coefficient is taken as a negative value. The larger the adjusted coefficient of variation, the stronger the adaptability of enterprises.

$$Adapt = -\frac{\sigma}{mean} \tag{4}$$

In equation (4), σ is the standard deviation of R&D expenditure intensity, capital expenditure intensity and sales expenditure intensity, and mean is the average of the three. In the equation, capital expenditure intensity = capital expenditure / operating revenue, and sales expenditure intensity = selling expenses/operating revenue.

4.2.4. Control variables

In order to ensure the unbiased estimation results, we control the variables that may affect the technological catch-up of enterprises. Specifically, they include: firm scale (Size), firm age (Age), asset liability ratio (Lev), profitability (Roa), asset circulation rate (Current), equity concentration (Top1), and firm nature (Soe). In addition, this research also controls the fixed effects at the industry, year and firm levels, and the standard errors of all regression models in this work are adjusted by clustering at the company level. Specific variable definitions are shown in Table 2.

Table 2
Variable definition.

Variable type	Variable name	Variable symbol	Variable definition
Dependent variable	Technological catch-up	Gap	Calculated from formula (1)
Independent variable	New quality productivity	Nqpf	Using entropy method to calculate the new quality productivity of enterprises
Mediating variable	Absorptive capacity	Absorb	R&D expenditure/operating income
	Innovation capacity	Innovation	Sum of R&D expenditure intensity and proportion of technical personnel after standardization
	Adaptive capacity	Adapt	Negative variation coefficient of R&D, capital and sales expenditure intensity
Control variable	Firm scale	Size	Natural logarithm of total assets
	Firm age	Age	Natural logarithm of the years of establishment of the enterprise
	Asset liability ratio	Lev	Total liabilities/total assets
	Profitability	Roa	Net profit/total assets
	Asset circulation rate	Current	Current assets/total assets
	Equity concentration	Top1	Shareholding ratio of the largest shareholder
	Firm nature	Soe	Take 1 for state-owned enterprises and 0 for non-state-owned enterprises

4.3. Research model

First, in order to verify the impact of new quality productivity on technological catch-up of latecomers, we build the following model:

$$Gap_{ijt}=\alpha_0+\alpha_1\times Nqpf_{it}+\alpha\times Control_{it}+Ind+Year+Firm+\varepsilon_{it} \quad (5)$$

In equation (5), i , j and t represent the enterprise, industry and year respectively. *Control* represents a series of control variables. *IND*[1], *Year* and *Frim* are the fixed effects at the industry, year and enterprise levels respectively, and ε_{it} is the residual term. It should be noted that the dependent variable technological catch-up (Gap) is a negative indicator. When the regression coefficient α_1 between new quality productivity and technological catch-up is significantly negative, it indicates that the improvement of new quality productivity has narrowed the technological gap between the sample enterprises and the leading-edge enterprises in the industry, that is, new quality productivity can enable latecomers to achieve technological catch-up. Research hypothesis H1 will be verified.

[1] Industry dummy variables are set in accordance with the Industry Classification Standard of the China Securities Regulatory Commission (2012), with a total of 71 industry dummy variables established.

Secondly, referring to the research methods of Wen and Ye (2014), we build the following model to test the mediating effect of dynamic capabilities:

$$M_{it}=\beta_0+\beta_1\times Nqpf_{it}+\beta\times Control_{it}+Ind+Year+Firm+\varepsilon_{it} \quad (6)$$

$$Gap_{ijt}=\gamma_0+\gamma_1\times Nqpf_{it}+\gamma_2\times M_{it}+\gamma\times Control_{it}+Ind+Year+Firm+\varepsilon_{it} \quad (7)$$

In equations (6) and (7), *M* are the dynamic capabilities, which refers to absorptive capability, innovation capability, and adaptive capability respectively. According to Wen and Ye (2014) , on the basis of the regression results of equation (5), if the regression coefficient β_1 of the intermediary variable (M) and the new quality productivity (Nqpf) in equation (6) is significantly positive, and the regression coefficient γ_2 of the technological catch-up (Gap) and the intermediary variable (M) in equation (7) is significantly negative, it shows that the new quality productivity can promote enterprises to achieve technological catch-up through improving dynamic capabilities, and the research hypothesis H2 will be verified. In addition, if the regression coefficient of new quality productivity (Nqpf) in equation (7) is smaller than that in equation (5) and is not significant, it indicates that dynamic capabilities play a complete intermediary role. If the regression coefficient of new quality productivity (Nqpf) decreases but is still significant, it indicates that dynamic capabilities play a partial intermediary role.

5. Empirical Results

5.1. Descriptive statistical analysis

Table 3 reports the descriptive statistical results of the main variables. (1) The minimum value of technological catch-up (Gap) is 1.0000; the maximum value is 1.6758; the average value is 1.2645; and the standard deviation is 0.1420. It shows that compared with the leading-edge enterprises in the industry, the technological level of most late-developing enterprises has been struggling to catch up for a long time. (2) The minimum value of new quality productivity (Nqpf) is 0.0014, the maximum value is 0.0152; the mean value is 0.0053; and the standard deviation is 0.0021. It shows that there is a large gap in the level of new quality productivity among different enterprises, and the overall level of new quality productivity of Chinese enterprises is low, which has large room for improvement. In addition, the statistical results of other variables are basically consistent with the existing literature.

Table 3
Descriptive statistics.

Variables	Obs	Mean	Std.Dev.	Min	P50	Max
Gap	21,090	1.2645	0.1420	1.0000	1.2599	1.6758
Nqpf	21,090	0.0053	0.0021	0.0014	0.0050	0.0152
Absorb	21,090	0.0288	0.0382	0.0000	0.0161	0.2242
Innovation	21,090	0.0004	0.0003	0.0000	0.0003	0.0016
Adapt	21,090	-0.7590	0.3129	-1.4142	-0.7586	-0.0034
Size	21,090	22.3176	1.2518	20.1434	22.1096	26.3217
Age	21,090	2.8996	0.3100	1.9459	2.9444	3.5264
Lev	21,090	0.4150	0.1867	0.0644	0.4099	0.8525

Table 3. (continued)

Variables	Obs	Mean	Std.Dev.	Min	P50	Max
Roa	21,090	0.0430	0.0637	-0.2243	0.0406	0.2280
Current	21,090	0.5744	0.1755	0.1394	0.5846	0.9231
Top1	21,090	0.3309	0.1426	0.0824	0.3096	0.7208
Soe	21,090	0.3019	0.4591	0.0000	0.0000	1.0000

5.2. Baseline regression

Table 4 reports the test results of new quality productivity on technological catch-up. Column (1) is the test result with only core independent variables. It can be found that the regression coefficient between Nqpf and Gap is -3.2063, which is significant at the 1% level. It means that the improvement of new quality productivity will help to narrow the technological gap between latecomers and frontier enterprises. That is, new quality productivity promotes the technological catch-up of enterprises. Column (2) is the test result of adding core independent variables and related control variables. The regression coefficient between Nqpf and Gap is still significantly negative at the 1% level, which once again confirms that new quality productivity can significantly promote technological catch-up of enterprises. Column (3) reports the test results after controlling for fixed effects at the industry, year, and enterprise levels on the basis of column (2). It can be found that the regression coefficient between Nqpf and Gap is still significantly negative at the 1% level, and the estimated results remain unchanged. To sum up, the regression results show that the improvement of new quality productivity can significantly narrow the technological gap between latecomers and frontier enterprises, enabling latecomers to achieve technological catch-up. Research hypothesis H1 is verified.

Table 4
Regression results of new quality productivity and technological catch-up.

Variables	(1) Gap	(2) Gap	(3) Gap
Nqpf	-3.2063***	-2.7094***	-2.7044***
	(-6.7339)	(-8.2159)	(-3.9029)
Size		-0.0727***	-0.0747***
		(-1.1e+02)	(-29.6700)
Age		0.0189***	-0.0762***
		(8.6915)	(-4.6553)
Lev		-0.1238***	-0.0733***
		(-27.2540)	(-8.8778)
Roa		-0.4004***	-0.2684***
		(-34.2150)	(-21.2685)
Current		-0.1222***	-0.1507***
		(-30.7558)	(-17.8902)
Top1		0.0049	0.0203
		(1.0142)	(1.5122)

Table 4. (continued)

Variables	(1) Gap	(2) Gap	(3) Gap
Soe		-0.0127***	0.0023
		(-7.9271)	(0.5468)
Constant	1.2814***	2.9883***	3.2876***
	(474.6356)	(193.4472)	(48.2169)
Ind / Year / Firm	N	N	Y
N	21,090	21,090	21,090
Adj-R2	0.0021	0.5534	0.8932

Note: ***, ** and * are significant at the levels of 1%, 5% and 10%, respectively. The two tailed test t value is shown in brackets. The standard error is clustered at the company level, the same below.

5.3. Robustness tests

5.3.1. Propensity score matching method

In order to alleviate the endogenous problem caused by the sample self-selection bias, we use the propensity score matching (PSM) method to test. First, we set the dummy variable (Nqpf_dum) as the treatment variable according to whether the new quality productivity is greater than the annual median of the industry. Secondly, we take the firm scale (Size), firm age (Age), asset liability ratio (Lev), profitability (Roa), asset circulation rate (Current), equity concentration (Top1), and firm nature (Soe) as covariates, and carry out 1:1 nearest neighbor matching, kernel matching and radius matching. The absolute value of the standardized deviation of all covariates after matching is within 3%, and the T-test results show that there is no significant difference in the characteristic variables of the two groups of samples after matching, which met the common support hypothesis and the parallel hypothesis.

We use the matched samples for regression test again, and the results are shown in Table 5. It can be seen from columns (1) to (3) of Table 5 that the regression coefficients of Nqpf are significantly negative at the 1% level. This means that after controlling for the selectivity error caused by observable factors, the conclusion of this study is still valid.

5.3.2. Instrumental variables method

To address endogeneity bias caused by omitted variables and reverse causality, this research employs the instrumental variable method for estimation. The authors use the lagged term of new quality productivity (L.Nqpf) and the average new quality productivity of firms in the same region and year (Nqpf_pro) as instrumental variables for endogeneity testing. The logic for their construction is that the lagged one-period new quality productivity level may affect firms' investment proportion in cultivating and developing new quality productivity in the future, but it is unlikely to have a significant impact on firms' future technological catch-up. Similarly, firms' new quality productivity levels exhibit regional heterogeneity due to the influence of regional characteristics, and firms within the same region mostly have competitive relationships. Therefore, the development of new quality productivity levels among firms in the same region is likely to affect a firm's own investment proportion in cultivating new quality productivity, but it is unlikely to have a direct impact on the technological catch-up outcomes of individual firms. Thus, both instrumental variables satisfy the requirements of relevance and exogeneity.

The two-stage least squares (2SLS) method is used for instrumental variable testing, and the results of the instrumental variable method are shown in columns (4) and (5) of Table 5.

The test results show that the F-statistic for the exclusivity test is 433.97, which significantly rejects the null hypothesis, indicating that the instrumental variables pass the exogeneity test; the value of the Kleibergen-Paap rk LM statistic is 324.677, which significantly rejects the null hypothesis, indicating that there is no under-identification issue with the instrumental variables; the value of the Cragg-Donald Wald F statistic is 2441.974, which is greater than the critical value of the weak instrumental variable test, indicating that there is no weak instrumental variable issue. This implies that selecting "lagged one-period new quality productivity" and "average new quality productivity of firms in the same region and year" as instrumental variables is reasonable and valid. As shown in column (4) of Table 5, in the first-stage regression, the regression coefficients of lagged one-period new quality productivity (L.Nqpf) and the average new quality productivity of firms in the same region and year (Nqpf_pro) are 0.2630 and 0.4416, respectively, both significant at the 1% level, which is consistent with theoretical expectations. As shown in column (5) of Table 5, in the second-stage regression, the regression coefficient of new quality productivity (Nqpf) on technological catch-up (Gap) is -3.3124, significant at the 5% level, which is consistent with the previous conclusions. This indicates that after further controlling for potential endogeneity issues, the research conclusions of this study remain robust.

Table 5
Test results of propensity score matching method and instrumental variable method.

Variables	**(1) 1:1 nearest neighbor matching Gap**	**(2) Kernel matching Gap**	**(3) Radius matching Gap**	**(4) Instrumental variables method Nqpf**	**(5) Instrumental variables method Gap**
Nqpf	-3.1590***	-2.7143***	-2.7143***		-3.3124**
	(-3.5697)	(-3.9151)	(-3.9151)		(-2.0778)
L.Nqpf				0.2630***	
				(5.5065)	
Nqpf_pro				0.4416***	
				(27.9258)	
Size	-0.0735***	-0.0747***	-0.0747***	-0.0002***	-0.0714***
	(-22.6704)	(-29.6654)	(-29.6654)	(-4.2535)	(-24.9378)
Age	-0.0720***	-0.0764***	-0.0764***	-0.0002	-0.0714***
	(-3.6644)	(-4.6677)	(-4.6677)	(-0.6459)	(-3.8156)
Lev	-0.0827***	-0.0733***	-0.0733***	-0.0001	-0.0620***
	(-7.6019)	(-8.8792)	(-8.8792)	(-0.6676)	(-6.8213)
Roa	-0.2711***	-0.2685***	-0.2685***	-0.0009***	-0.2505***
	(-16.5021)	(-21.2649)	(-21.2649)	(-5.6792)	(-19.4152)
Current	-0.1448***	-0.1505***	-0.1505***	-0.0027***	-0.1501***
	(-14.1111)	(-17.8423)	(-17.8423)	(-17.7521)	(-15.0156)
Top1	0.0242	0.0204	0.0204	0.0005***	0.0145
	(1.3746)	(1.5199)	(1.5199)	(2.7993)	(1.0489)

Table 5. (continued)

Variables	(1) 1:1 nearest neighbor matching Gap	(2) Kernel matching Gap	(3) Radius matching Gap	(4) Instrumental variables method Nqpf	(5) Instrumental variables method Gap
Soe	0.0001	0.0020	0.0020	-0.0001*	0.0031
	(0.0165)	(0.4732)	(0.4732)	(-1.7420)	(0.6939)
Constant	3.2518***	3.2886***	3.2886***	0.0073***	
	(39.3433)	(48.1950)	(48.1950)	(6.6300)	
F test of excluded instruments				433.97***	
Kleibergen-Paap rk LM statistic				324.677***	
Cragg-Donald Wald F statistic				2441.974>19.93(critical value)	
Ind / Year / Firm	Y	Y	Y	Y	Y
N	10,916	21,080	21,080	16,296	16,296
Adj-R2	0.8924	0.8932	0.8932	0.8712	0.2826

5.3.3. Granger causality test

We employ the Granger causality test to further rule out endogeneity issues that may arise from reverse causality between new quality productivity and the technological catch-up of latecomer firms. The lag order is determined as the 5th order based on the information criterion, and Table 6 presents the results of the Granger causality test between variables. As shown in Table 6, in the test involving new quality productivity (Nqpf) and the technological catch-up of latecomer firms (Gap), the test fails to reject the null hypothesis that the technological catch-up of latecomer firms is not a factor affecting new quality productivity, while the test rejects the null hypothesis that new quality productivity (Nqpf) does not affect the technological catch-up of latecomer firms at the 5% significance level. In other words, the Granger causality test results indicate that there is no statistically significant reverse causality between new quality productivity and the technological catch-up of latecomer firms. The core conclusion of this research is robust.

Table 6
Test result of granger causality.

Null hypothesis	X^2	P value	Judgment of causality
Nqpf is not Granger causality for *Gap*.	13.184	0.022	Reject the null hypothesis.
Gap is not Granger causality of *Nqpf*.	3.784	0.581	Accept the null hypothesis.

5.3.4. Replacing dependent variable

First, we use the total factor productivity of 95th percentile enterprises in various industries and the ratio of total factor productivity of 90th percentile enterprises to total factor productivity of various enterprises to remeasure technological catch-up, which are recorded as Gap95 and Gap90 respectively. Multiple regression analysis is conducted for equation (5) again, and the results are shown in Table 7.

It can be seen from columns (1) and (2) of Table 7 that the regression coefficients of Nqpf are -2.0950 and -1.1919 respectively, which are significant at least at the 5% level, consistent with the benchmark regression results. The research hypothesis H1 is still valid. It shows that the research conclusions of this research are robust.

Second, to avoid measurement errors in the technological catch-up variable and enhance the robustness of the empirical results, this research further uses the gap in the number of patent applications between catch-up firms and frontier firms to measure technological catch-up. Specifically, technological catch-up is remeasured using the ratio of the number of patent applications of firms at the 99th percentile, 95th percentile, and 90th percentile in each industry to the number of patent applications of each firm, denoted as TGap99, TGap95, and TGap90 respectively. We reconduct regression analysis using Model (5), and the test results are shown in Table 7. As shown in columns (3) to (5) of Table 7, the regression coefficients of new quality productivity (Nqpf) are all significantly negative at the 1% level, consistent with the baseline regression results. Research hypothesis H1 still holds, indicating that the research conclusions of this study are robust.

Table 7
Test results of replacing dependent variable.

Variables	(1) Gap95	(2) Gap90	(3) TGap99	(4) TGap95	(5) TGap90
Nqpf	-2.0950***	-1.1919**	-55.3406***	-54.1064***	-47.8720***
	(-3.3147)	(-2.0165)	(-4.7421)	(-5.0676)	(-4.5847)
Size	-0.0707***	-0.0675***	-0.1489***	-0.1582***	-0.1584***
	(-30.2195)	(-31.5342)	(-3.6477)	(-4.1887)	(-4.2610)
Age	-0.0643***	-0.0599***	-0.0745	0.1785	0.3211
	(-4.3346)	(-4.5299)	(-0.2312)	(0.6172)	(1.1425)
Lev	-0.0745***	-0.0655***	0.3373**	0.2728**	0.2233*
	(-9.9373)	(-9.2981)	(2.5295)	(2.2428)	(1.8600)
Roa	-0.2525***	-0.2266***	-0.8385***	-0.6929***	-0.3771**
	(-21.3396)	(-20.3091)	(-4.1498)	(-3.7412)	(-2.0978)
Current	-0.1350***	-0.1285***	-0.5228***	-0.4419***	-0.3627***
	(-17.7633)	(-18.4652)	(-3.6434)	(-3.3490)	(-2.7927)
Top1	0.0287**	0.0194	0.1032	0.1763	-0.0492
	(2.3224)	(1.6315)	(0.4158)	(0.7503)	(-0.2078)
Soe	0.0025	0.0046	-0.0234	0.0050	0.0254
	(0.6849)	(1.3938)	(-0.2956)	(0.0697)	(0.3777)
Constant	3.0781***	2.9369***	7.3599***	5.8862***	4.9064***
	(48.5696)	(49.7037)	(5.8235)	(5.1325)	(4.4347)
Ind / Year / Firm	Y	Y	Y	Y	Y
N	21,090	21,090	21,090	21,090	21,090
Adj-R2	0.8881	0.8877	0.7490	0.7276	0.7227

5.3.5. Extended time window

The technological catching-up of latecomers has a long cycle, and the impact of new quality productivity on the technology catching up of latecomers may lag. In order to test the dynamic effect and long-term impact of new quality productivity on the technological catch-up of latecomers, we lag the new quality productivity by 2 to 4 periods, advance the technological catch-up of enterprises by 2 to 4 periods, and use equation (5) to conduct multiple regression analysis again. The test results are shown in Table 8. From columns (1) to (6) of Table 8, it can be seen that the regression coefficients of new quality productivity are significantly negative at least at the 5% significance level, which means that the improvement of new quality productivity can significantly narrow the technological gap between latecomers and frontier enterprises, and effectively enable latecomers to achieve technological catch-up. It shows that the research conclusion has strong robustness and long-term effect.

Table 8
Test results of extending time window.

Variables	(1) Gap95	(2) Gap90	(3) TGap99	(4) TGap95	(5) TGap90
Nqpf	-2.0950***	-1.1919**	-55.3406***	-54.1064***	-47.8720***
	(-3.3147)	(-2.0165)	(-4.7421)	(-5.0676)	(-4.5847)
Size	-0.0707***	-0.0675***	-0.1489***	-0.1582***	-0.1584***
	(-30.2195)	(-31.5342)	(-3.6477)	(-4.1887)	(-4.2610)
Age	-0.0643***	-0.0599***	-0.0745	0.1785	0.3211
	(-4.3346)	(-4.5299)	(-0.2312)	(0.6172)	(1.1425)
Lev	-0.0745***	-0.0655***	0.3373**	0.2728**	0.2233*
	(-9.9373)	(-9.2981)	(2.5295)	(2.2428)	(1.8600)
Roa	-0.2525***	-0.2266***	-0.8385***	-0.6929***	-0.3771**
	(-21.3396)	(-20.3091)	(-4.1498)	(-3.7412)	(-2.0978)
Current	-0.1350***	-0.1285***	-0.5228***	-0.4419***	-0.3627***
	(-17.7633)	(-18.4652)	(-3.6434)	(-3.3490)	(-2.7927)
Top1	0.0287**	0.0194	0.1032	0.1763	-0.0492
	(2.3224)	(1.6315)	(0.4158)	(0.7503)	(-0.2078)
Soe	0.0025	0.0046	-0.0234	0.0050	0.0254
	(0.6849)	(1.3938)	(-0.2956)	(0.0697)	(0.3777)
Constant	3.0781***	2.9369***	7.3599***	5.8862***	4.9064***
	(48.5696)	(49.7037)	(5.8235)	(5.1325)	(4.4347)
Ind / Year / Firm	Y	Y	Y	Y	Y
N	21,090	21,090	21,090	21,090	21,090
Adj-R2	0.8881	0.8877	0.7490	0.7276	0.7227

6. Mechanism Testing

In the research hypothesis part, we elaborated that the new quality productivity can enable latecomers to achieve technological catch-up by improving the absorptive capacity, innovation capacity, and adaptability of latecomers. Based on this, we will use the step-by-step method to test whether the transmission mechanism of three-dimensional dynamic capabilities, such as absorptive capacity, innovation capacity, and adaptive capacity, is established between the new quality productivity and the technological catch-up of latecomers.

Table 9 shows the results of the mediation effect test of dynamic capabilities. Firstly, columns (1) and (2) in Table 9 are the estimated results with absorptive capacity as the mediating variable. It can be found that in column (1) of Table 9, the regression coefficient of Nqpf is 3.2528 and significant at the 1% level, indicating that the new quality productivity improves the absorptive capacity of enterprises. In column (2) of Table 9, the regression coefficient of Absorb is -0.0631, which is significant at the 5% level when the absorptive capacity and new quality productivity are added to the regression in the regression of enterprise technological catch-up. The regression coefficient of Nqpf is 2.4993 and significant at 1% level. It shows that the new quality productivity can promote enterprises to achieve technological catch-up and surpassing by improving the absorptive capacity.

Secondly, columns (3) and (4) in Table 9 are the estimated results with innovation capacity as the mediation variable. It can be found that in column (3) of Table 9, the regression coefficient of Nqpf is 0.0255 and significant at the 1% level, indicating that new quality productivity improves the innovation ability of enterprises. In column (4) of Table 9, the regression coefficient of Innovation is -8.2740 and significant at the 5% level when the innovation capacity and new quality productivity are added to the regression in the regression of enterprise technological catch-up. The regression coefficient of Nqpf is -2.4937 and significant at the 1% level. It shows that new quality productivity can promote enterprises to achieve technological catch-up and surpassing by improving innovation ability.

Finally, columns (5) and (6) in Table 9 are the estimated results with adaptive capacity as the mediation variable. It can be found that in column (5) of Table 9, the regression coefficient of Nqpf is 0.0407, which is significant at the 1% level, indicating that the new quality productivity improves the adaptive capacity of enterprises. In column (6) of Table 9, the regression coefficient of Adapt is -0.0154 and significant at the 1% level when the adaptive capacity and new quality productivity are added to the regression in the regression of enterprise technological catch-up. The regression coefficient of Nqpf is -0.0049 and significant at the 1% level. It shows that the new quality productivity can promote enterprises' technological catch-up and surpassing by improving their adaptive capacity.

Table 9
Mediation effect test results of dynamic capabilities.

Variables	(1) Absorb	(2) Gap	(3) Innovation	(4) Gap	(5) Adapt	(6) Gap
Nqpf	3.2528***	-2.4993***	0.0255***	-2.4937***	0.0407***	-0.0049***
	(10.4428)	(-3.5866)	(9.6459)	(-3.5446)	(8.6526)	(-3.4826)
Absorb		-0.0631**				
		(-1.9905)				
Innovation				-8.2740**		
				(-1.9723)		
Adapt						-0.0154***
						(-5.1896)
Size	0.0012	-0.0746***	0.0000***	-0.0745***	-0.0307***	-0.0752***

Table 9. (continued)

Variables	(1) Absorb	(2) Gap	(3) Innovation	(4) Gap	(5) Adapt	(6) Gap
	(1.5947)	(-29.6840)	(2.8870)	(-29.5115)	(-3.8623)	(-30.0548)
Age	0.0295***	-0.0743***	0.0001**	-0.0753***	0.2116***	-0.0729***
	(4.1794)	(-4.5506)	(2.2253)	(-4.6049)	(3.7781)	(-4.4757)
Lev	-0.0063**	-0.0737***	0.0000	-0.0730***	-0.0040	-0.0733***
	(-2.2076)	(-8.9203)	(1.5060)	(-8.8529)	(-0.1511)	(-8.9163)
Roa	-0.0722***	-0.2729***	0.0000	-0.2683***	-0.1230***	-0.2702***
	(-13.1436)	(-21.1886)	(0.2049)	(-21.2493)	(-3.1506)	(-21.4259)
Current	0.0067**	-0.1503***	0.0001***	-0.1501***	0.2020***	-0.1476***
	(2.0119)	(-17.8903)	(2.8515)	(-17.8042)	(6.7020)	(-17.5948)
Top1	-0.0148***	0.0194	-0.0001	0.0199	-0.0617	0.0194
	(-3.4078)	(1.4462)	(-1.4437)	(1.4784)	(-1.3652)	(1.4481)
Soe	-0.0017	0.0022	-0.0000	0.0023	0.0223	0.0027
	(-0.8477)	(0.5234)	(-0.0682)	(0.5466)	(1.4471)	(0.6231)
Constant	-0.0944***	3.2816***	-0.0005***	3.2832***	-0.7825***	3.2612***
	(-3.6063)	(48.1656)	(-2.6185)	(47.9571)	(-3.3897)	(48.5815)
Ind / Year / Firm	Y	Y	Y	Y	Y	Y
N	21,090	21,090	21,090	21,090	21,090	21,090
Adj-R2	0.7886	0.8932	0.8337	0.8932	0.6664	0.8935

7. Heterogeneity Analysis

7.1. Uncertainty of external environment

The uncertainty of the external environment is an important factor affecting the technological innovation of enterprises (Gong *et al*., 2021). It is worth noting that for latecomers, the unstable, complex and unpredictable external environment is both an opportunity and a threat. The formation and development of new productivity is the key driving factor for them to maintain survival and establish competitive advantage. Jaworski and Kohli (1993) believe that environmental uncertainty mainly comes from the uncertainty of market environment and technology environment. For this reason, we examine the heterogeneous impact of uncertainty in different market and technological environments on the relationship between new quality productivity and technological catch-up.

7.1.1. Market environment uncertainty

The instability and irregular changes of the market environment will inevitably lead to the fluctuation of the company's core business, which will be reflected in the fluctuation of the company's operating income. Therefore, drawing on the research of Shen *et al*. (2012), we use the coefficient of variation of the company's sales revenue in the past five years adjusted by the industry median to measure the market environment uncertainty faced by the company. Column (1) of Table 10 reports the test results of the moderating effect of market environment uncertainty on the relationship between new quality productivity and enterprises' technological catch-up. It can be found that the regression coefficient of Nqpf is significantly negative at the 5% level, and the regression coefficient of NqpfMarketeu is significantly negative at the 10% level, indicating that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where market uncertainty exists.

The reason for this is that under high market environment uncertainty, the market orientation and consumer preferences develop and change rapidly, the elimination rate of products is accelerated, and the value of the original products will depreciate rapidly with the change of consumer demand. At this time, consumer groups prefer new, innovative, and higher quality products and services. The goal and foothold of new quality productivity is to provide more products and services with high quality, high performance, high reliability, high safety, and high environmental protection, and better meet and create effective demand. Undoubtedly, it has brought a stronger driving force for latecomers to achieve technological catch-up, helping latecomers to gain market share or seize consumer groups and markets that have not been occupied by cutting-edge enterprises, so as to form a competitive advantage to achieve catch-up.

7.1.2. Technological environment uncertainty

Technical environment uncertainty refers to the unpredictability of the speed of technological innovation, development path and iteration direction in the environment where the company is located (Jaworski and Kohli, 1993; Zhang and Wu,2024). Therefore, based on the research of Shi *et al*. (2024), we use the coefficient of variation of patent applications in the past five years adjusted by the industry median to measure the technical environment uncertainty faced by the company (Techeu). Table 10 reports the test results of the moderating effect of technical environment uncertainty on the relationship between new quality productivity and technological catch-up. It can be found that the regression coefficient of Nqpf is significantly negative at the 5% level, and the regression coefficient of NqpfTecheu is significantly negative at the 5% level, indicating that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where technological uncertainty exists. The reason is that, on the one hand, under high technological environment uncertainty, the rapid technological update and iteration has greatly shortened the life cycle of the original products, but also weakened the competitive advantage of the leading-edge enterprises in the industry, which has provided the first opportunity for the latecomers. On the other hand, the highly uncertain technology environment creates a huge space for latecomers to develop and expand new productivity. At the same time, the emergence of new technologies and market opportunities also helps latecomers to acquire innovative knowledge, shorten the learning curve, and accelerate the process of technology catching-up and surpassing.

7.2. Internal resource heterogeneity

The effective acquisition, allocation, and transformation of internal resources are also crucial to whether latecomers can achieve technological catch-up (Barney, 1991). Therefore, this research introduces two internal factors (redundant resources and executive political relationships), to investigate the heterogeneous impact of the company's unique internal resources on the relationship between new productivity and technological catch-up of latecomers.

7.2.1. Slack resources

We use the current ratio to measure the slack resources of enterprises (Hernandez-Vivanco and Bernardo, 2022). Column (3) of Table 10 reports the test results of the moderating effect of slack resources on the relationship between new productivity and enterprise technology catch-up. It can be found that the regression coefficient of Nqpf is significantly negative at the 10% level, and the regression coefficient of NqpfSlack is significantly negative at the 5% level, indicating that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where slack resources exist. The reason is that slack resources can provide additional resources for listed companies to try new strategies and carry out more original, breakthrough and disruptive technological innovation activities (Tabesh *et al*., 2019). With the support of slack resources, latecomers can effectively reduce the resources competition and coordination costs between different innovation projects, and are more likely to carry out new product research and development or implement the development strategy of entering new markets, and ultimately achieve technological catch-up. Therefore, slack resources can significantly enhance the role of new quality productivity in promoting technological catch-up of latecomers.

7.2.2. Executive political relationships

Referring to Liu *et al*. (2021), if the actual controller, chairman or CEO of the sample company are former or current government officials, deputies to the National People's Congress and members of the Chinese People's Political Consultative Conference, it indicates that the sample company has political relationships, and the executive political relationships variable (PC) is assigned a value of 1, otherwise it is assigned a value of 0. Column (4) of Table 10 reports the test results of the moderating effect of senior management's political relationships on the relationship between new quality productivity and enterprises' technological catch-up. It can be found that the regression coefficient of Nqpf is significantly negative at the 1% level, and the regression coefficient of Nqpf×PC is significantly negative at the 1% level, indicating that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the cases where executive political relationships exist. The reason is that as an informal institutional arrangement, political relationships are an important channel for enterprises to get informed of and apply for tax incentives, government subsidies, industry access qualifications and other government innovation support (Su *et al*., 2019; Li *et al*., 2021). Therefore, enterprises with political relationships can leverage more innovation resources at a lower cost. This can stimulate the motivation and willingness of the latecomer enterprises' technological innovation, and promote their technological catch-up. In addition, enterprises with senior executives' political relationships can also give priority to learning more industry cutting-edge information, changes in industrial innovation policies and relevant innovation strategic initiatives (Chen *et al*., 2024), which is conducive to enterprises' seizing the first opportunity and giving full play to the first mover advantage, providing an opportunity for enterprises' technological catch-up. Therefore, the political relationships of senior executives can significantly enhance the promotion of new quality productivity to the technological catch-up of latecomers.

Table 10
Test results of external environmental uncertainty and internal resource heterogeneity.

Variables	(1) Gap	(2) Gap	(3) Gap	(4) Gap
Nqpf	-2.0009**	-1.7103**	-1.5170*	-2.1266***
	(-2.5624)	(-1.9786)	(-1.9299)	(-2.8268)
Nqpf×Marketeu	-0.5359*			
	(-1.6747)			

Table 10. (continued)

Variables	(1) Gap	(2) Gap	(3) Gap	(4) Gap
Marketeu	0.0007			
	(0.3631)			
Nqpf×Techeu		-0.9713**		
		(-1.9902)		
Techeu		0.0100***		
		(3.5816)		
Nqpf×Slack			-0.4694**	
			(-2.3788)	
Slack			0.0108***	
			(8.5702)	
Nqpf×PC				-2.3965***
				(-2.5811)
PC				0.0135**
				(2.4508)
Size	-0.0740***	-0.0739***	-0.0762***	-0.0747***
	(-29.1268)	(-29.4823)	(-30.8791)	(-29.6894)
Age	-0.0764***	-0.0730***	-0.0708***	-0.0757***
	(-4.6571)	(-4.4540)	(-4.4149)	(-4.6265)
Lev	-0.0721***	-0.0731***	-0.0227**	-0.0732***
	(-8.7472)	(-8.8527)	(-2.4250)	(-8.8591)
Roa	-0.2672***	-0.2707***	-0.2519***	-0.2678***
	(-21.2069)	(-21.3749)	(-20.1877)	(-21.2741)
Current	-0.1511***	-0.1526***	-0.1868***	-0.1511***
	(-17.9864)	(-18.1751)	(-20.9380)	(-17.9513)
Top1	0.0221*	0.0177	0.0195	0.0201
	(1.6465)	(1.3223)	(1.4691)	(1.4961)
Soe	0.0023	0.0025	0.0010	0.0023
	(0.5381)	(0.5717)	(0.2319)	(0.5353)
Constant	3.2700***	3.2525***	3.2807***	3.2841***
	(47.6499)	(47.7187)	(49.2629)	(48.1030)
Ind / Year / Firm	Y	Y	Y	Y
N	21,090	21,090	21,090	21,090
Adj-R2	0.8933	0.8935	0.8953	0.8932

8. Conclusion and Implication

The emergence of new quality productivity is driven by technological revolutionary breakthroughs, innovative allocation of production factors, and deep industrial transformation and upgrading. Can the cultivation and development of new quality productivity promote the technological catch-up of latecomer enterprises? This article takes Chinese A-share listed companies from 2011 to 2022 as samples, and empirically tests for the first time the impact of new quality productivity on the technological catch-up of latecomer enterprises and the underlying mechanism. The research results indicate that the improvement of new quality productivity could significantly narrow the technological gap between latecomer enterprises and frontier enterprises, empowering latecomer enterprises to achieve technological catch-up. After a series of robustness tests via approaches such as propensity score matching, instrumental variable method, and extended time window, the above conclusion still holds true. Mechanism testing found that new quality productivity mainly promotes technological catch-up among latecomer enterprises by improving three-dimensional dynamic capabilities such as absorption capacity, innovation capacity, and adaptability. Further analysis reveals that the effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where market/technological uncertainty, slack resources, and executive political relationships exist.

The research conclusion of this article has important practical implications for listed companies to cultivate and develop new quality productivity and achieve technological catch-up:

(1) Latecomer enterprises should recognize the critical in-depth enabling impact of new quality productivity on their technological catch-up. They must take new quality productivity as a core strategic focus and consolidate the foundation for technological catch-up through two-way synergy between their own strategic layout and government policy guidance. Firstly, latecomer enterprises should align with the development of industrial frontiers and build innovation ecosystems. Specifically, on the one hand, they should proactively engage in investment and cooperation in strategic emerging industries and future industries, precisely grasp the rhythm of industrial resource allocation, and obtain technological competitive edge; on the other hand, they should jointly establish development platforms for new quality productivity with innovative enterprises, technology incubators, and venture capital institutions, transforming technological catch-up momentum into sustained competitive advantages. Secondly, government departments should enhance policy guidance and orchestrate the entire innovation chain. The government needs to play dual roles of guarantee and guidance: By fostering enterprises' awareness of independent innovation, introducing targeted support policies, and coordinating technological R&D, large-scale application, and scenario construction, it can promote more latecomer enterprises to convert new quality productivity into momentum for technological catch-up, forming a "innovation → application → catch-up" virtuous cycle.

(2) Dynamic capabilities serve as the key bridge connecting new quality productivity and technological catch-up. Latecomer enterprises must enhance dynamic capabilities in three aspects to ensure the materialization of this enabling impact. Firstly, enhance knowledge integration and resource absorption capacities. Break path dependence in internal knowledge acquisition processes, efficiently absorb valuable external knowledge, information and resources, and lay the groundwork for technological innovation. Secondly, strengthen original and disruptive technological innovation capabilities. Focus on breakthroughs in key core technologies, cultivate the core driving force of new quality productivity, and activate endogenous innovation capacity through original and disruptive innovations to adapt to the needs of organizational transformation caused by changes in the external environment. Thirdly, improve strategic flexibility and environmental adaptability. Proactively respond to dynamic disruptions in the market and technological environment, dynamically adjust strategic choices to match external changes, drive the transformation of production models toward high-end, intelligent, and green orientations, accelerate product and service innovation, and swiftly respond to market demands.

(3) Government departments should tailor their efforts to the various needs of enterprises with different

endowments and external environments, and implement targeted regulation to unlock the enabling potential of new quality productivity. Firstly, map out category-specific guidance based on enterprise endowments: For enterprises with abundant slack resources or political affiliations, efforts should be made to leverage their resource value and amplify the positive impact of new quality productivity on technological catch-up; for enterprises with limited resources or lacking political affiliations, guidance should focus on enhancing dynamic capabilities to drive the implementation of new quality productivity through capability breakthroughs. Secondly, make dynamic adjustments to guidance based on external environments: The effect of new quality productivity on technological catch-up in latecomer firms is more prominent in the environments where market/technological uncertainty exist. Therefore, the government is advisable to keep the dynamic development of the environment within a controllable range, establish a competition-oriented incentive system for technological innovation, promote the free flow of various factor resources and a full and orderly competition, continuously stimulate enterprises' willingness to engage in technological innovation and boost market vitality, and fully unleash the enabling effect of new quality productivity on the technological catch-up of latecomer firms.

Conflicts of interest

The authors declare no conflict of interest.

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