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# New external driving force of enterprises' commercial innovation: Revealing the role of internet platforms

Fang Zhao [a], Guoliang Jiang [a], Yi Xu [a], Wanying Ma [b,*]

[a] School of Economics, Jilin University, Changchun, 130012, China
[b] School of Business, Changchun Guanghua University, Changchun, 130033, China

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ABSTRACT

As digital platforms continue to evolve, they facilitate the exchange of information and create opportunities for innovation-driven growth and introduce new challenges for enterprises navigating research and development-driven transformation. In the study, we used the Probit model, IV-Probit model, propensity score matching (PSM) model, KHB model to conduct research and discussion based on 2015 China Private Enterprise Survey (CEPS), and conducted a systematic investigation of the mechanisms that Internet platforms affect enterprises. Focusing on the mechanisms through which widespread digital platform adoption influences corporate commercial innovation, we first identify the pathways through which internet platforms enhance enterprises' commercialization and innovation capabilities. Specifically, internet platforms improve the external market environment by increasing the frequency and quality of information exchange between enterprises and consumers. In addition, these platforms strengthen enterprises' motivation and confidence, which encourages increased investment in innovation. Moreover, integrating "visible hand" (government intervention) and "invisible hand" (market forces) factors, we demonstrate that the positive effects of internet platforms on commercialization and innovation are more pronounced when government support for enterprises is intensified. Conversely, a more developed and competitive market environment magnifies firms' propensity to accelerate innovation using digital platforms. Expanding the scope of our analysis, we introduce industry, enterprise size, type of internet platform, and geographical location dimensions to enable a more nuanced understanding of how company-specific characteristics influence the impact of digital platforms on commercial innovation. These expanded analyses significantly enhance the practical relevance and operational applicability of our findings, providing deeper insights into how firm attributes mediate the influence of digital platforms on innovation outcomes. Finally, we propose a set of strategies and frameworks for using digital platforms to facilitate the rapid recovery of enterprise operations and bolster innovation capabilities in the post-COVID-19 era.

## Introduction

The 21st century has often been heralded as the digital age, characterized by profound societal transformations driven by advancements in information and communication technologies. This era represents the most significant leap forward since the industrial revolution, influencing every facet of human existence, from daily life to global economics. At the forefront of this evolution are enterprises; pivotal economic agents grappling with the imperative of digital and intelligent transformation to remain competitive in an increasingly interconnected world (Zhao et al., 2023). Jack Ma, the founder of Alibaba Group, underscored the urgency for enterprises to harness data-driven strategies for upgrading management, organizational structures, and product offerings. He asserted that the current decade marks a critical juncture for traditional businesses to undergo comprehensive digital transformations. Concurrently, the development of internet platforms introduced new paradigms for enterprises' operations, facilitating direct consumer engagement and reshaping traditional business–consumer dynamics (Ali et al., 2023; Cenamor et al., 2019).

Scholarly inquiry into enterprise digital transformation has become a focal point, reflecting its pivotal influence on aligning with digital economic trends and navigating dynamic market environments (Zhuo et al.,

* Corresponding author at: Changchun Guanghua University, 3555 Wuhan Road, Changchun Economic and Technological Development Zone, Jilin Province, China.
*E-mail address:* 18043848160@163.com (W. Ma).

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2023). Successful digital transformation necessitates responsive and expedient development and execution of digital strategies to ensure seamless integration to reconfigure business architectures and capitalize on emerging opportunities (Correani et al., 2020). This evolution has often been delineated into stages of digitization, digitalization, and digital transformation, each of which poses distinct challenges and opportunities for enterprises' adaptation to evolving consumer preferences and market demands (Verhoef et al., 2021). The impact of digital transformation on enterprise innovation capabilities is an essential area of investigation for determining its role in enhancing innovation quality, absorption capacity, and adaptive resilience (Li et al., 2023; Peng et al., 2022). This transformation integrates advanced information technologies with core business functions and enhances environmental, social, and governance performance, bolstering enterprises' sustainable competitive advantages in the Industry 4.0 landscape (Ghobakhloo et al., 2020; Fang et al., 2023).

However, along with transformative benefits, digital transformation presents challenges such as heightened skill requirements and potential market exclusion for smaller enterprises that lack digital readiness (Atasoy et al., 2016; Ghobakhloo et al., 2020). Moreover, the emergence of internet platforms has disrupted traditional business models, intensifying competitive pressure and necessitating accelerated business model innovations to maintain relevance and market competitiveness (Cenamor et al., 2019). Considering these developments, investigating internet platforms as catalysts for enterprises' commercial innovation is crucial. Their influence spans organizational structures, market behaviors, and consumer interactions, underscoring their pivotal role in accelerating business model transformation and directly impacting commercial innovation capabilities across enterprises (Ali et al., 2023). Moreover, it is essential to understand how governmental and market dynamics shape these impacts to shed light on the heterogeneous effects of internet platforms on enterprises' innovation strategies and outcomes (Jin et al., 2023).

In summary, this study examines the evolving landscape of enterprises' digital transformation and the transformative influence of internet platforms on reshaping business operations and innovation dynamics. The study meets the imperative of further research to identify the mechanisms through which internet platforms influence enterprises' commercial innovation capabilities to inform strategies for sustainable growth and competitiveness in the digital era. First of all, we will build a theoretical framework to analyze the influence of Internet platform on enterprise's commercial innovation, and consider the role of invisible (government) and invisible (market) hands in it. Secondly, we use various methods to analyze and test the 2015 China Private Enterprise Survey (CEPS) to verify our theoretical hypothesis. Finally, according to our research conclusions, the corresponding countermeasures and suggestions are put forward.

## *Internet platforms and corporate commercial innovation: a theoretical analysis*

### *Analyzing internet platforms and corporate commercial innovation from external environment and corporate dynamics perspectives*

Extensive research has demonstrated that the factors influencing corporate commercial innovation predominantly include internal and external environmental factors. Internal factors encompass research and development (R&D) investment intensity, emphasis on innovation, and R&D personnel allocation, while external factors include market order, consumer feedback, and competitive pressure (Popa et al., 2017; Soto et al., 2018). Accordingly, this study explores the pathways through which internet platforms impact corporate commercial innovation from the external environment (market information feedback) and internal corporate dynamics (corporate development motivation).

From the external environment perspective, it is evident that market feedback is a crucial concern for companies and directly influences their survival and growth (Ferraris et al., 2022). Enterprises' primary objective is profitability, necessitating alignment with market (consumer) preferences to innovate products, capture consumer favor, and achieve higher profits (Teece, 2018). Consequently, the ability to quickly gather market information and obtain consumer feedback on products is pivotal for advancing corporate commercial innovation. The advent of internet platforms has transcended previous communication barriers between companies and consumers, facilitating expedient acquisition of consumer opinions and accelerating product innovation based on feedback to seize greater market share.

Internet platforms serve as bridges for company–consumer interaction, enabling companies to sell products and consumers to purchase goods (Ha et al., 2022). Concerning negative externalities, social media platforms and various external networks have become significant driving forces for service iteration and product innovation. In an uncertain market, active information channels are a strong guarantee to support enterprises' resilience (Aurora et al., 2024). Additionally, online shopping platforms allow consumers to submit reviews, express opinions, identify products' shortcomings, and share postpurchase experiences (Rosario et al., 2016). Therefore, companies can scrutinize consumer comments to identify deficiencies and innovate products accordingly, accelerating the commercial innovation process (Wang et al., 2022; Qi et al., 2016). Furthermore, combined with the data for other products sold on the internet platform, enterprises can be keenly aware of the advantages and characteristics of competing external products (You et al., 2015) and further clarify the different market acceptance of products in the same period, transforming platform algorithm results into the production and investment decisions. Platforms' feedback information enables enterprises to identify the best-selling products as the benchmark for promoting product innovation and improving sales (Chen et al., 2023). The platforms' algorithm can facilitate decision-making processes, aid enterprises' effective customer loss information management, clearly target user characteristics, and further apply platform-based data to product and decision-making innovation (Kozak et al., 2021).

From the perspective of corporate dynamics, corporate development motivation is essential for advancing innovation and directly influences investment in innovation talent, funds, and technology, impacting the quality of enterprises' commercial innovation (Aghion et al., 2023). Stronger enterprise development power will advance business innovation, fully integrating platform crossover resources and digital platforms to accelerate enterprises' collaboration. Increased market competition pressure objectively enhances enterprises' development confidence and reverses the transition to concentrated capital value, which strengthens enterprises' unique advantages and market competitiveness (Fisch et al., 2020; Mayer et al., 2014).

Internet platforms enable similar companies to sell products on the same platform, simultaneously presenting all products to consumers. In this scenario, consumers establish preferences, tending to choose products with lower prices and superior performance (Bawack et al., 2023), which accelerates the market's elimination of higher-priced, poorer-performing products. Therefore, online sales significantly intensify market competition pressure. As market competition pressure escalates, companies must engage in commercial innovation to adapt to the market, avoid elimination, increase market share, and meet consumer preferences, considerably accelerating commercial innovation (Cornaggia et al., 2015). Furthermore, internet platforms enable large companies to use dynamic marketing methods to explore business opportunities, further open the market, and expand sales channels to enhance the power of business innovation. The internet also enables small and medium-sized enterprises (SMEs) to better integrate into the price difference production network, identify arbitrage links in the production supply chain, and leverage additional market opportunities to establish broader development prospects (Nikita et al., 2023; Wang et al., 2016). Therefore, internet platforms can invigorate corporate development motivation, objectively accelerate commercial innovation, and drive companies to achieve development goals.

Based on our analysis, we propose the following hypotheses:

**Hypothesis 1**. Internet platforms significantly enhance corporate commercial innovation.

**Hypothesis 2**. Enhanced market information feedback and increased corporate development motivation are two pivotal mechanisms through which internet platforms accelerate corporate commercial innovation.

*Internet platforms and corporate commercial innovation: considering the influence of visible (government) and invisible (market) hands*

Our theoretical analysis indicates that internet platforms can accelerate corporate commercial innovation and augment innovation capabilities. However, it is imperative to acknowledge that the visible hand (government) and the invisible hand (market) have significant influence on corporate commercial innovation (Doh et al., 2014; Blind et al., 2017). Different companies are heterogeneously affected by government and market influences, necessitating a nuanced analysis.

Regarding the visible hand (government), while innovation is an intrinsic corporate activity reflecting individual characteristics and variation, with final innovation decisions made internally, the government can also provide critical support for corporate innovation. Strategic policies can mitigate market deficiencies, alleviate the adverse effects of market failures on corporate development, dismantle industrial monopolies and market segmentation, and establish an environment that promotes innovation. Additionally, inclusive policy support such as tax incentives and procurement policies can mobilize corporate innovation motivation and willingness.

In contrast, the invisible hand (market) functions as the direction and benchmark for corporate innovation. Companies compete in the market on product quality, price, and service to earn higher profit and market share, which compels them to optimize resource allocation, improve production efficiency, and continuously innovate to meet market demand. This competitive dynamic drives companies to increase market share and achieve long-term development.

Based on our analysis, we propose the following hypotheses:

**Hypothesis 3.1**. The impact of internet platforms on commercial innovation differs due to heterogeneous government influence on different companies.

**Hypothesis 3.2**. The impact of internet platforms on commercial innovation differs due to heterogeneous market influence on different companies.

## Research methods and model construction

### *Data source*

The primary dataset employed in this study is the 2015 China Private Enterprise Survey (CEPS). The original data comes from the research center of private entrepreneurs in China Academy of Social Sciences. This data is a survey of private enterprises in China, which is open to users at home and abroad, to reflect the basic characteristics and development of enterprises. We chose this dataset for its comprehensive coverage of private enterprises across various facets of production, operations, sales, innovation, finance, management, and training. It also provides detailed insights into entrepreneurs' personal characteristics and their perspectives on market dynamics, enterprise development, and future strategies (Zhao et al., 2024). Spanning 28 provinces in China, the CEPS encompasses a diverse array of industries, encompassing mining, real estate, warehousing, leasing, business services, telecommunications, internet services, electricity, agriculture, finance, transportation, and catering. Therefore, the CEPS offers extensive geographical and sectoral coverage, has a robust sample size, and ensures the essential data continuity and comparability for rigorous empirical analysis.

We use provincial data on post and telecommunications offices from 1984 as an instrumental variable (IV) for the internet platform variable in regression models. These data are sourced from the 1985 China Urban Statistics Yearbook. Data cleaning involved initial filtering of the CEPS dataset, handling missing values and outliers, and integrating provincial office data to construct the final analytical sample. Finally, we got 4915 valid research samples, covering manufacturing, finance, service, transportation and other industries, and these enterprises are distributed in different regions of China, such as eastern, central and western regions. At the same time, the number of employees in these enterprises is also quite different, ranging from large enterprises with more than 100 employees to small enterprises with less than 10 employees, and the establishment time of each enterprise is also different, which has strong representativeness and can cover the basic categories of most enterprises.

### *Variables*

#### *Dependent variable: commercial innovation*

We operationalize commercial innovation using the CEPS "Successful R&D but unsuccessful commercialization" item. A value of 1 indicates the presence of commercial innovation, while 0 signifies its absence. Sensitivity analyses substitutes this measure with indicators that include "Introduction of new products into production" (coded as 1 for yes, 0 for no) and "Revenue increase attributable to innovation" (coded as 1 for yes, 0 for no) to validate our findings' robustness.

#### *Independent variable: internet platform*

The internet platform variable measurement references the CEPS item "Sales through third-party e-commerce platforms," which is coded as 1 if the enterprise engaged in such platforms and 0 if it did not. Additional robustness tests employ alternative measures of "Presence of online sales channels" (coded as 1 for yes, 0 for no) and "Participation in networked platforms" (coded as 1 for yes, 0 for no).

#### *Control variables*

Control variables include "Technical imitation ease," "Employee training," "Dedicated R&D staff presence," "Emphasis on employee innovation capabilities," and "High-tech enterprise designation." These variables are selected to mitigate potential confounding effects based on established research frameworks (Xiong et al., 2023; Li et al., 2023).

First, within the realm of corporate innovation research, the complexity of technological innovation is a crucial determinant influencing firms' strategic choices. In sectors characterized by prolonged innovation cycles and foundational technological attributes, firms must judiciously allocate financial resources, balancing the constraints of capital acquisition with economic return considerations. Consequently, firms adopt distinct innovation strategies based on the interplay between technological complexity and market imperatives as demonstrated by Matos et al. (2022). Second, extensive research has highlighted the pivotal role of R&D team heterogeneity in sustaining firms' innovation momentum (Zhou et al., 2024; Herfert et al., 2008). Firms with R&D teams that have higher qualifications, stronger practical expertise, and more sophisticated organizational structures are better equipped to leverage digital platform resources and establish more effective internal innovation frameworks. However, examining firms' interactions with digital platforms within market systems necessitates controlling for internal structural variations. To do so, we introduce factors of employee training, dedicated R&D personnel, and organizational emphasis to examine their influence on employee innovation capabilities as control variables. Finally, recognizing firms' diverse operational objectives, high-tech enterprises are a distinct category that is driven by a commitment to technological breakthroughs and innovation as a core competitive advantage while navigating the dual influence of market demand and administrative imperatives. Unlike other market entities, whose R&D initiatives are primarily motivated by

internal incentives and external competition, high-tech enterprises operate under compounded pressure (Lin et al., 2020). Therefore, high-tech firms are treated as a unique control variable that is distinct from other sampled entities.

*Mediating variables*

Mediating analysis include "Enhanced market feedback mechanism" and "Strengthened internal development drive," which we measure using indicators of market information accessibility and intentions for business expansion from the 2015 CEPS dataset.

Table 1 summarizes the descriptive statistics of all variables used in this study.

## Regression model

This study examines the impact of integrating internet platforms and adopting online sales methodologies on enterprises' commercial innovation. Considering that the dataset used in this study is derived from survey data and includes several binary variables, we employ the probit model for binary choice regression, referencing pertinent studies (Gomila et al., 2021; Shin et al., 2018). Specifically, we construct the following model to empirically assess the influence of internet platforms on enterprises' commercial innovation:

$$Pro(Commercial\ innovation = 1) = \varnothing\left(\beta_0 + \beta_1 Internet\ platform + \beta_2 M + \sum \alpha_j X_j + \mu\right), \quad (2)$$

$$Pro(Commercial\ innovation = 1) = \varnothing\left(\alpha_0 + \alpha_1 Internet\ platform + \sum \alpha_j X_j + \mu\right), \quad (1)$$

where Commercial innovation denotes the commercial innovation status within an enterprise. If Commercial innovation = 1, this indicates that the enterprise has engaged in commercial innovation, and if Commercial innovation = 0, it indicates that the enterprise has not undertaken commercial innovation. Internet platform represents the enterprise's use of internet platforms, where Internet platform = 1 signifies that the enterprise employs internet platforms for sales, and Internet platform = 0 indicates no internet platform use. Regression coefficient α1 for Internet platforms denotes the impact of internet platforms on enterprises' commercial innovation. A statistically significant α1 indicates that internet platforms have a considerable influence on commercial innovation, whereas an insignificant α1 implies no such impact. X encompasses the range of control variables that are integral to this study, including the ease of Technical imitation, Employees train, dedicated R&D staff, emphasis on employee innovation capabilities (Degree of imitation), and enterprises' high-tech classification. These control variables are essential as they significantly influence enterprises' propensity for commercial innovation.

Furthermore, to rigorously examine the proposed mechanisms of market feedback and internal development, we adopt the KHB method from Karlson (2010, 2012) and Kohler (2011), which can identify mediating effects within nonlinear probability models and effectively mitigate sample selection bias issues. The method also rectifies endogeneity concerns that arise from omitted variable bias and reverse causality, rendering it appropriate for application in the probit model framework. The specific formulation is as follows:

where M denotes the proposed mediating mechanisms of market feedback and internal development impetus enhancement. The specifications for the remaining variables are consistent with those in Eq. (1). Eq. (2) will determine the validity of our proposed mechanisms.

With these rigorous models, we examine the pathways through which internet platforms influence commercial innovation, contributing to a more nuanced understanding of the interplay between digitalization and enterprise innovation dynamics.

**Table 1**
Descriptive statistics.

| Variable | Sample size | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| *Commercial innovation* | 4915 | 0.1392 | 0.3462 | 0 | 1 |
| *Internet platform* | 4915 | 0.0568 | 0.2314 | 0 | 1 |
| *Employees train* | 4915 | 0.6531 | 0.4760 | 0 | 1 |
| *R&D staff* | 4915 | 0.6456 | 0.4784 | 0 | 1 |
| *Degree of attention* | 4915 | 4.7278 | 1.7595 | 1 | 7 |
| *Technical imitation* | 4915 | 0.1194 | 0.3243 | 0 | 1 |
| *High-tech enterprise* | 4915 | 0.0916 | 0.2884 | 0 | 1 |
| *Market feedback* | 4915 | 0.6716 | 0.4697 | 0 | 1 |
| *Development impetus* | 4915 | 0.2767 | 0.4474 | 0 | 1 |

## Empirical regression results

*Baseline regression*

To rigorously test our proposed hypotheses and evaluate whether internet platforms accelerate corporate commercial innovation, we employ a probit model for regression analysis. Table 2 presents the detailed results. Column (1) examines the impact of internet platforms on commercial innovation without including control variables. The regression coefficient of Internet platforms is positive and significant at the 1% level, indicating that internet platforms markedly enhance firms' commercial innovation capabilities. This enhancement supports firms' navigation of complex market dynamics through commercial innovation, which promotes long-term, sustainable development.

In columns (2)–(7), we sequentially introduce potential influencing factors. The coefficient of Internet platform remains significantly positive across all regressions, reinforcing the conclusion that internet platforms significantly bolster corporate commercial innovation capabilities, independent of other variables.

Analyzing the control variables reveals that employees' professional training, dedicated R&D personnel, and high-tech enterprise status have significant positive effects on firms' commercial innovation. While dedicated R&D personnel generally contribute positively to commercial innovation, the magnitude of this effect is relatively modest and

**Table 2**
Benchmark regression.

| | (1) *Commercial innovation* | (2) *Commercial innovation* | (3) *Commercial innovation* | (4) *Commercial innovation* | (5) *Commercial innovation* | (6) *Commercial innovation* |
|---|---|---|---|---|---|---|
| *Internet platform* | 0.4917*** | 0.1658*** | 0.4645*** | 0.4644*** | 0.4930*** | 0.4131*** |
| | (0.0840) | (0.0486) | (0.0843) | (0.0846) | (0.0850) | (0.0869) |
| *dy/dx* | 0.1081*** | 0.1014*** | 0.1018*** | 0.1012*** | 0.1069*** | 0.0877*** |
| | (0.0184) | (0.0184) | (0.0184) | (0.0184) | (0.0183) | (0.0184) |
| *Employees train* | | 0.0363*** | 0.1665*** | 0.1619*** | 0.1899*** | 0.1611*** |
| | | (0.0106) | (0.0485) | (0.0487) | (0.0494) | (0.0499) |
| *R&D staff* | | | 0.0466 | 0.0439 | 0.0408 | 0.0498 |
| | | | (0.0471) | (0.0472) | (0.0474) | (0.0478) |
| *Degree of attention* | | | | 0.0607*** | 0.0575*** | 0.0598*** |
| | | | | (0.0134) | (0.0134) | (0.0135) |
| *Technical imitation* | | | | | −0.3694*** | −0.4670*** |
| | | | | | (0.0812) | (0.0847) |
| *High-tech enterprise* | | | | | | 0.6270*** |
| | | | | | | (0.0701) |
| Clustered robust standard errors | Y | Y | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0083 | 0.0112 | 0.0115 | 0.0169 | 0.0229 | 0.0425 |
| Constant | −1.1190*** | −1.2289*** | −1.2599*** | −1.5482*** | −1.5138*** | −1.5697*** |
| | (0.0233) | (0.0403) | (0.0505) | (0.0829) | (0.0834) | (0.0837) |
| Observations | 4915 | 4915 | 4915 | 4915 | 4915 | 4915 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

**Table 3**
Robustness test I: changing variable measurement methods.

| | Changing the measurement approach for the dependent variable. | | Changing the measurement approach for the independent variable. | |
|---|---|---|---|---|
| | (1) *Commercial innovation* | (2) *Commercial innovation* | (3) *Commercial innovation* | (4) *Commercial innovation* |
| *Internet platform* | 0.4361*** | 1.3796*** | 0.2261*** | 0.4631*** |
| | (0.0793) | (0.0849) | (0.0508) | (0.0472) |
| *dy/dx* | 0.1461*** | 0.2793*** | 0.0480*** | 0.0965*** |
| | (0.0263) | (0.0159) | (0.0108) | (0.0097) |
| Control variable | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0372 | 0.1073 | 0.0421 | 0.0614 |
| Constant | −0.5665*** | −1.4485*** | −1.6602*** | −1.7779*** |
| | (0.0661) | (0.0847) | (0.0859) | (0.0886) |
| Observations | 4915 | 4915 | 4915 | 4915 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

sometimes statistically insignificant. Furthermore, the ease of technical imitation negatively impacts commercial innovation. These findings validate Hypothesis 1.

## Robustness tests

To validate the robustness of the baseline findings, we conduct a series of robustness tests employing alternative variable specifications, propensity score matching (PSM), different estimation techniques, and IVs. Detailed results of all robustness checks are presented in Tables 3–7.

### *Robustness test I: alternative variable specifications*

To mitigate the potential bias associated with singular variable specifications, we systematically vary the operational definitions of

**Table 5**
Average treatment effect.

| | (1) Nearest neighbor matching | (2) Radius matching | (3) Kernel matching |
|---|---|---|---|
| Average treatment effect | 0.2652*** | 0.2653*** | 0.2652*** |
| t-value | 3.37 | 1.87 | 4.39 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

**Table 4**
Balance test.

| Variable | Sample | Mean | No commercial innovation | Standard deviation (%) | Deviation reduction (%) | Different t-value tests | |
|---|---|---|---|---|---|---|---|
| | | Commercial innovation | | | | t-value | p-value |
| Employees train | Prematching | 0.8280 | 0.6426 | 42.9 | 96.1 | 6.34 | 0.000 |
| | Postmatching | 0.8280 | 0.8351 | −1.7 | | −0.23 | 0.821 |
| R&D staff | Prematching | 0.6057 | 0.6480 | −8.7 | 91.5 | −1.43 | 0.152 |
| | Postmatching | 0.6057 | 0.6022 | 0.7 | | 0.09 | 0.931 |
| Degree of attention | Prematching | 4.8070 | 4.7230 | 4.6 | 91.4 | 0.77 | 0.442 |
| | Postmatching | 4.8065 | 4.8136 | −0.4 | | −0.05 | 0.964 |
| Technical imitation | Prematching | 0.2330 | 0.1126 | 32.2 | 100.0 | 6.04 | 0.000 |
| | Postmatching | 0.2330 | 0.2330 | −0.0 | | 0.00 | 1.000 |
| High-tech enterprise | Prematching | 0.2258 | 0.0835 | 40.1 | 95.0 | 8.06 | 0.000 |
| | Postmatching | 0.2258 | 0.2186 | 2.0 | | 0.20 | 0.839 |

**Table 6**
Robustness test: alternative regression methods.

| | (1) Logit model Commercial innovation | (2) OLS model Commercial innovation | (3) Tobit model Commercial innovation | (4) Poisson model Commercial innovation | (5) Negative binomial model Commercial innovation |
|---|---|---|---|---|---|
| Internet platform | 0.7332*** | 0.1140*** | 0.1140*** | 0.5376*** | 0.5376*** |
| | (0.1506) | (0.0212) | (0.0212) | (0.1264) | (0.1264) |
| Control variable | Y | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y | Y |
| $R^2$ | 0.0428 | 0.0383 | 0.0546 | 0.0341 | 0.0341 |
| Constant | −2.7112*** | 0.0436*** | 0.0436*** | −2.7171*** | −2.7170*** |
| | (0.1595) | (0.0167) | (0.0167) | (0.1461) | (0.1461) |
| Observations | 4915 | 4915 | 4915 | 4915 | 4915 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

**Table 7**
Instrumental variable test.

| First-stage | Commercial innovation | Second-stage | Commercial innovation |
|---|---|---|---|
| post | 0.0131*** | Internet platform | 5.1462** |
| | (0.0039) | | (2.6236) |
| F-statistics | 21.57 | AR statistics | 6.35** |
| Control variables | Y | Wald statistics | 3.85** |
| Clustered robust standard errors | Y | Control variable | Y |
| $R^2$ | 0.0257 | Clustering robust standard error | Y |
| Constant | 0.0367*** | Constant | −1.4711*** |
| | (0.0124) | | (0.1144) |
| Observations | 4915 | Observations | 4915 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

dependent and independent variables to perform regression analyses, presenting the results in Table 3. In columns (1) and (2), we respectively define the dependent variable as "Introduction of new products into production" and "Effect of innovation on enhanced company revenue," and measure independent variables were measured as "Engagement in online sales" and "Membership in affiliate marketing platforms." The results reveal statistically significant positive coefficients of Internet platforms at the 1% significance level across all regression models. This reaffirms the substantial role of internet platforms in augmenting firms' commercial innovation capabilities and accelerating the pace of such innovations, validating the benchmark findings of this study.

*Robustness test II: propensity score matching*

Next, referencing Abadie (2016) and Shipman (2017), we employ PSM to conduct regression analysis. Specifically, we use three matching methods based on whether firms engaged in commercial innovation, encompassing nearest neighbor matching within a caliper, kernel matching, and radius matching. Firms with commercial innovation are assigned to the treatment group, and those without commercial innovation are assigned to the control group. We then conduct balance diagnostics to assess the comparability between these groups, as presented in Table 4.

Prior to matching, significant imbalances are observed across all control variables, indicating substantial differences between the treatment and control groups; however, postmatching, the control variable distribution between treatment and control groups becomes more homogeneous, with closer proximity in means, enhancing the accuracy of our estimates.

Fig. 1 presents a graph illustrating changes in each variables' standardized deviation. The figure visually reveals that the standardized deviations of all control variables notably decrease after matching. Furthermore, the standardized deviations are more dispersed prior to matching, whereas after matching, they predominantly concentrate around zero, indicating that our regression estimates are likely to be more accurate after employing PSM.

The average treatment effect on the treated (ATT) using three matching strategies is detailed in Table 5. Each matching method reveals isolated instances in which samples fall outside the common support range. Postmatching, the standard deviations of all variables are below 10%, and the *t*-tests for all variables do not reject the null hypothesis, confirming satisfactory balance across groups.

Figs. 2 and 3 illustrate the kernel density curves before and after

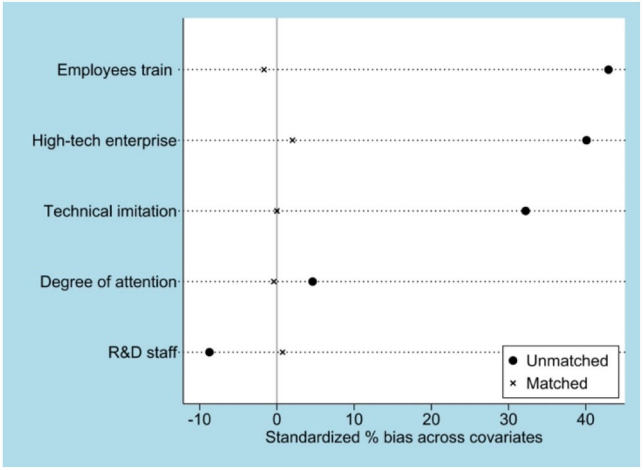


**Fig. 1.** Changes in each variable's standardized deviation.

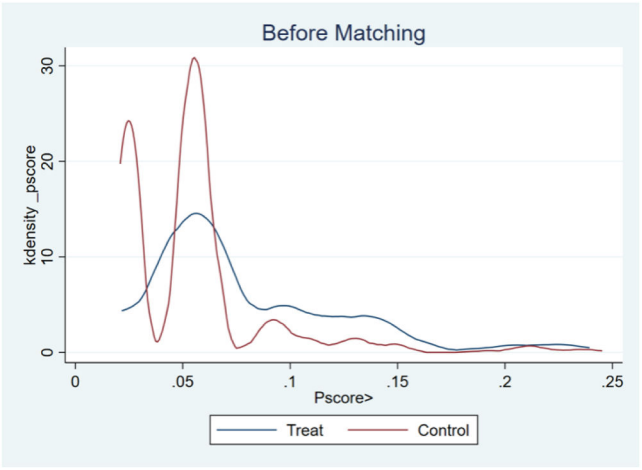


**Fig. 2.** Kernel density curve before matching.

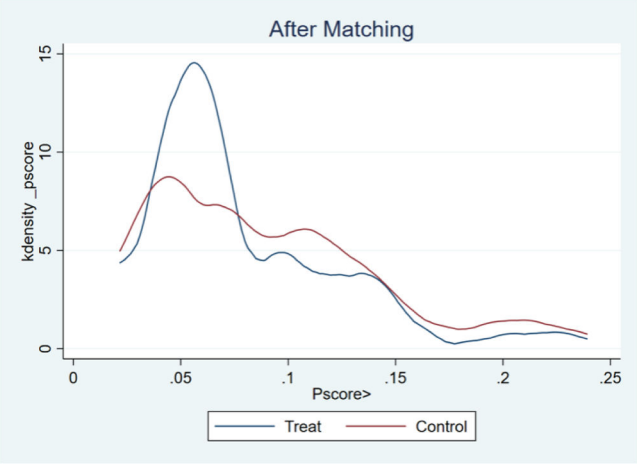


**Fig. 3.** Kernel density curve after matching.

matching, with kernel matching employed as an example. The substantial deviations between the kernel density curves observed prematching are significantly reduced postmatching, as the curves align more closely. This evidence suggests that our matching procedure is effective, demonstrating high matching quality.

*Robustness test III: alternative regression methods*

To address potential biases that may arise from relying solely on a single estimation method, which could compromise the accuracy of our research conclusions, we next employ various regression estimation methods. Specifically, we conduct regression analyses using logit, ordinary least squares (OLS), Tobit, Poisson, and negative binomial models, presenting the detailed results in Table 6.

Table 6 reveals that the coefficient of Internet platform remains significantly positive across all regression models. This consistency with the results of the baseline regression indicates that our research conclusions are robust and not influenced by the chosen regression method, demonstrating robust accuracy.

*Robustness test IV: addressing endogeneity*

The central explanatory variable in our study is whether firms engage in commercial innovation. In practice, a firm's decision to pursue commercial innovation is intricately linked with factors such as firm size, debt ratio, profitability, and geographical location. Despite incorporating numerous determinants of commercial innovation to alleviate endogeneity concerns, residual nonrandom factors may still introduce significant bias into our estimations. To mitigate this issue, we employ the number of post offices in China in 1984 as an IV, presenting the detailed results in Table 7.

**Table 8**
Mediating mechanisms.

| | Commercial innovation | Proportion |
|---|---|---|
| Total effect | 0.4166*** | |
| | (0.0902) | |
| Direct effect | 0.2675*** | 64.21% |
| | (0.0908) | |
| Indirect effect | 0.1491*** | 35.79% |
| | (0.0353) | |
| Market feedback | 0.0271*** | 6.51% |
| | (0.0082) | |
| Development impetus | 0.1219*** | 29.26% |
| | (0.0219) | |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

As shown in Table 7, the coefficient of Internet platform remains significantly positive after applying the IV approach, indicating that our benchmark conclusions remain robust against potential endogeneity concerns such as reverse causality and omitted variable bias.

## Further analyses

*Mechanism analysis*

We previously demonstrated that internet platforms enhance market information feedback, enabling firms to gain more insights into consumer responses to their products, which accelerates enterprises' product innovation and enhanced commercialization capabilities. Furthermore, internet platforms intensify market competition, compelling firms to expedite development and raise growth aspirations to increase market share. To examine these mechanisms, we employ the KHB model for regression analysis, presenting the results in Table 8.

Table 8 reveals that the total effect of internet platforms on firms' commercial innovation is 0.4166, with a direct effect of 0.2675 and an indirect effect of 0.1491. The direct effect accounts for 64.21%, and the indirect effect accounts for 35.79%. Among the indirect effects, the mediating effect of market information feedback is 0.0271, accounting for 6.51%, and the mediating effect of firm development impetus is 0.1219, accounting for 29.26%.

These results indicate that internet platforms' direct impact on firms' commercial innovation behavior is stronger than the indirect impact. Furthermore, within the indirect impact mechanisms, firms' development impetus enhancement is the primary mediating mechanism, with a substantial proportion. This indicates that internet platforms significantly increase market pressure, stimulating firms' motivation for development, which subsequently facilitates rapid growth and accelerates commercial innovation. Conversely, the impact of improved market information feedback is relatively minimal, indicating that while enhanced market information feedback can accelerate firms' commercial innovation, its overall impact is comparatively limited.

*Heterogeneity analysis*

Considering the influences of visible (government) and invisible (market) hands on corporate innovation, firms experience diverse degrees of impact from government and market forces. To explore these differential effects, we employ a subgroup regression analysis to test hypotheses 3.1 and 3.2.

First, we conduct a series of subgroup analyses from the government influence perspective. To do so, we categorize firms based on whether the firm's technology development is included in government planning projects, dividing them into No and Yes groups to perform separate regression analyses. Second, we group firms based on whether the firm has received government subsidies, again divided into No and Yes groups for individual regression analyses. Finally, we categorize firms based on whether the firm perceives government policies as helpful, with separate regression analyses conducted for the No and Yes groups. Table 9 presents the detailed regression results.

Several key observations emerge from the results in Table 9. In the subgroup analysis based on whether the firm's technology development is included in government planning projects (columns (1) and (2)), the coefficient of Internet platform is insignificant for the No group, but significantly positive for the Yes group. This indicates that when a firm's technology development is included in government planning projects and receives government support, the positive impact of internet platforms on commercial innovation is markedly enhanced.

In the subgroup analysis based on whether the firm received government subsidies (columns (3) and (4)), the coefficient of Internet platform is insignificant for the No group, but significantly positive for the Yes group. This finding indicates that when a firm benefits from government subsidies and financial support, the internet platform's

**Table 9**
Heterogeneity analysis: visible hand (government).

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Inclusion of firms' technology development in government planning projects. | | Whether the firm received government subsidies. | | Whether firms perceive government policies as helpful. | |
| | No | Yes | No | Yes | No | Yes |
| | Commercial innovation | Commercial innovation | Commercial innovation | Commercial innovation | Commercial innovation | Commercial innovation |
| Internet platform | 0.2400 | 0.4969*** | 0.0369 | 0.5480*** | −0.0954 | 0.4687*** |
| | (0.1641) | (0.1038) | (0.1802) | (0.1006) | (0.2406) | (0.0969) |
| dy/dx | 0.0497 | 0.1064*** | 0.0073 | 0.1184*** | −0.0158 | 0.1066*** |
| | (0.0340) | (0.0221) | (0.0357) | (0.0216) | (0.0400) | (0.0219) |
| Control variables | Y | Y | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0429 | 0.0466 | 0.0326 | 0.0480 | 0.0296 | 0.0458 |
| Constant | −1.8529*** | −1.4394*** | −1.5604*** | −1.5725*** | −1.9344*** | −1.4940*** |
| | (0.1501) | (0.1016) | (0.1863) | (0.0931) | (0.1956) | (0.0931) |
| Observations | 1706 | 3209 | 1227 | 3688 | 1359 | 3556 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

**Table 10**
Heterogeneity analysis: invisible hand (market).

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Whether the industry's market competition is intense. | | Firms' perceptions of market maturity. | | Products' competitiveness in the market. | |
| | No *Commercial innovation* | Yes *Commercial innovation* | No *Commercial innovation* | Yes *Commercial innovation* | No *Commercial innovation* | Yes *Commercial innovation* |
| *Internet platform* | 0.2768 | 0.3997*** | 0.2303 | 0.4446*** | −0.0158 | 0.5884*** |
| | (0.2410) | (0.0951) | (0.2284) | (0.0944) | (0.1666) | (0.1046) |
| *dy/dx* | 0.0337 | 0.0954*** | 0.0448 | 0.0966*** | −0.0032 | 0.1270*** |
| | (0.0294) | (0.0226) | (0.0444) | (0.0204) | (0.0340) | (0.0223) |
| Control variables | Y | Y | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0219 | 0.0424 | 0.0304 | 0.0457 | 0.0357 | |
| Constant | −1.7947*** | −1.4992*** | −1.5444*** | −1.5686*** | −1.5732*** | −1.5845*** |
| | (0.1904) | (0.0946) | (0.1765) | (0.0950) | (0.1369) | (0.1065) |
| Observations | 1294 | 3621 | 1112 | 3803 | 1905 | 3010 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

positive influence on commercial innovation is significantly strengthened.

In the subgroup analysis based on whether the firm perceives government policies as helpful (columns (5) and (6)), the coefficient of Internet platform is insignificant for the No group but. significantly positive for the Yes group. This demonstrates that when a firm perceives government policies as beneficial and receives policy support, the positive impact of internet platforms on commercial innovation is considerably higher.

In summary, the results of these three subgroup analyses demonstrate that the visible hand (government) has a direct influence on the relationship between internet platforms and firms' commercial innovation. Enhanced government attention and support amplify the efficacy of internet platforms, bolster firms' commercial innovation capabilities, expedite the pace of commercial innovation, satisfy market demand, and foster corporate development, substantiating hypothesis 2.1.

To explore the impact of market dynamics from the invisible hand perspective, we conduct subgroup regression analyses. We categorize firms based on factors of industry competition intensity, perception of market maturity, and products' competitiveness in the market, resulting in distinct No and Yes groups for each category. Regression analyses are performed for each subgroup, and the findings are presented in Table 10.

The results from columns (1) and (2) in Table 10 reveal a notable pattern. Within the subgroup experiencing intense industry competition, the regression coefficient of Internet platform is insignificant for the No group but significantly positive for the Yes group. This implies that as competition intensifies and market pressure rises, the positive influence of internet platforms on fostering commercial innovation becomes stronger.

Similarly, comparisons in columns (3) and (4) reveal that in the subgroups for perceived market maturity, the regression coefficient of Internet platform is insignificant for the No group but significantly positive for the Yes group. This demonstrates that internet platforms have a more pronounced effect on promoting firms' commercial innovation in more mature and well-established markets.

Furthermore, the results in columns (5) and (6) highlight that within the subgroup characterized by competitive products in the market, the regression coefficient of Internet platform is insignificant for the No group but significantly positive for the Yes group. This demonstrates that firms with highly competitive products and strong consumer recognition tend to receive greater benefits from internet platforms in enhancing commercial innovation.

Synthesizing these findings across the three regression groups reveals that market dynamics exert a significant influence on the relationship between internet platforms and firms' commercial innovation. Specifically, as markets mature, competition intensifies, and product competitiveness strengthens, firms increasingly leverage internet platforms to innovate and meet market demand. These results substantiate hypothesis 2.2, confirming that the interplay between market conditions and internet platforms is pivotal for driving commercial innovation forward.

By systematically examining these interactions, this study

**Table 11**
Extended analysis: industry heterogeneity.

| Industry | Manufacturing *Commercial innovation* | Retail *Commercial innovation* | Finance *Commercial innovation* | Service *Commercial innovation* | Transportation *Commercial innovation* | Other industries *Commercial innovation* |
|---|---|---|---|---|---|---|
| *Internet platform* | 0.3526** | 0.4233*** | 0.3618 | 0.7834* | 0.6370 | 0.5516* |
| | (0.1393) | (0.1498) | (0.2669) | (0.4588) | (0.5341) | (0.2853) |
| *dy/dx* | 0.0733** | 0.0931*** | 0.0772 | 0.1850* | 0.0913 | 0.1201* |
| | (0.0289) | (0.0327) | (0.0568) | (0.1060) | (0.0767) | (0.0618) |
| Control variables | Y | Y | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0397 | 0.0389 | 0.0419 | 0.1150 | 0.1193 | 0.0407 |
| Constant | −1.5440*** | −1.5790*** | −1.5357*** | −1.9230*** | −2.8954*** | −1.3891*** |
| | (0.1214) | (0.1678) | (0.2969) | (0.4112) | (0.5152) | (0.2437) |
| Observations | 2194 | 1292 | 493 | 210 | 165 | 561 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

contributes to the broader understanding of how market forces interact with technological platforms to shape firms' innovation strategies.

*Extended analysis*

Thus far, this study has explored the relationship between internet platforms and firms' commercial innovation, analyzing the enhancement of corporate growth dynamics and improved market information feedback systems as key mechanisms. We also introduced visible (government intervention) and invisible (market forces) hands into the theoretical framework. To further enrich the research and enhance its practical and operational relevance, we introduce additional contextual factors into the analysis.

First, recognizing that the research sample spans multiple industries with substantially heterogeneous business models, marketing strategies, and operational frameworks, these interindustry differences may affect our conclusions. To address this issue, we disaggregate the sample based on industry classifications, dividing it into six groups of manufacturing, retail, finance, services, transportation, and other industries to test the applicability and robustness of the findings across different industrial contexts. We employ a probit regression model to examine these subgroups and present the results in Table 11.

The findings reveal notable industry-specific variations in the impact of internet platforms on firms' commercial innovation. For the retail industry, the regression coefficient of Internet platforms has the highest statistical significance, underscoring the substantial and pronounced influence of internet platforms on commercial innovation within this sector. In the manufacturing industry, the coefficient also reaches a significant level, indicating that internet platforms also have an important influence on facilitating commercial innovation in this domain. In the service industry, the regression coefficient of Internet platforms passes the 10% significance threshold, indicating that although internet platforms have a measurable impact on commercial innovation in the service sector, the magnitude of this effect is comparatively lower. Conversely, for finance and transportation industries, while the regression coefficients of Internet platforms are positive, they do not achieve statistical significance, indicating that internet platforms have no discernible impact on commercial innovation within these sectors during the study period.

These findings demonstrate heterogeneity in the effects of internet platforms on commercial innovation across different industries. Among the industries analyzed, the retail sector has the strongest impact, followed by manufacturing and services. In contrast, financial and transportation industries exhibit the weakest, and in some cases statistically insignificant, effects. These results highlight the nuanced and industry-specific nature of the relationship between internet platforms and commercial innovation.

Building on digital platforms' intrinsic characteristics, the rapid flow of information enables firms to identify industry trends more expediently, introducing heightened external competitive pressure while simultaneously fostering stronger intrinsic innovation drivers. Digital platforms also facilitate smoother interactions between firms and consumers. Particularly in retail and service industries, internet platforms can replicate the frequent communication and interaction patterns that are characteristic of traditional offline businesses. The real-time nature of data accelerates firms' transition from multichannel to omnichannel business models, enabling consumers to enjoy seamless user experiences with greater convenience. This evolution enhances consumer satisfaction and product compatibility, providing a stable feedback channel for obtaining consumer experiences and the transmission of demand insights. Consequently, firms can accelerate product innovation, swiftly respond to market demand, and drive disruptive changes in retail and service industries (Shi et al., 2019).

Considering the distinct features of the retail, service, and manufacturing industries, two key perspectives emerge. In the retail and service sectors, market-driven development emphasizes the leap in circulation efficiency from the synergy between platform expansion and commercialization. By integrating data transmission with supporting logistics resources, digital platforms enhance market vitality, enabling more platform users to benefit from the value of data resources. This can also facilitate the seamless market integration of previously disorganized production outputs, enabling household and gig-based production to benefit from more substantial market feedback. In contrast, manufacturing sector development highlights the role of the government as a resource coordinator, leveraging platforms to empower firms. Within the framework of Industry 4.0, technologies that require immense computational power such as cloud computing and the Internet of Things can operate effectively. Government collaboration with digital platforms can enhance production planning and supply chain control, integrating firms' digitalization into regional development strategies. This demonstrates the concentrated efficacy of digital platforms in promoting innovation (Moeufi et al., 2018).

Furthermore, firms' size is a critical factor influencing their capacity for commercial innovation, and has been widely recognized by scholars (Albats et al., 2023; Krawczyk et al., 2021). In terms of market operations, large enterprises must actively conduct exploratory innovation and use internet platforms to expand the depth and breadth of existing international markets, and innovation and dynamic marketing considerations have increased the difficulties for large enterprises to use internet platforms and resources (Mostafiz et al., 2024). In contrast, for SMEs facing stronger market competition pressure, how to cooperate with other enterprises to obtain supplementary resources to save costs and promote effective commercialization of innovation results has become an urgent concern (Dasgupta., 2023).

In terms of government support, previous research has indicated that fiscal policies and technological capabilities had varying impacts on economic entities of different scales during the COVID-19 pandemic. As significant contributors to regional business tax revenue, large

**Table 12**
Extended analysis: enterprise size.

| Enterprise size | Small and micro enterprises *Commercial innovation* | Medium-sized enterprises *Commercial innovation* | Large enterprises *Commercial innovation* | Ultralarge enterprises *Commercial innovation* |
|---|---|---|---|---|
| *Internet platform* | 0.4935*** | 0.4825*** | 0.3383 | 0.0243 |
| | (0.1403) | (0.1367) | (0.2716) | (0.3265) |
| *dy/dx* | 0.1044*** | 0.1040*** | 0.0686 | 0.0047 |
| | (0.0295) | (0.0293) | (0.0548) | (0.0631) |
| Control variables | Y | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y | Y |
| Pseudo $R^2$ | 0.0524 | 0.0462 | 0.0433 | 0.0499 |
| Constant | −1.5152*** | −1.6431*** | −1.5909*** | −1.4753*** |
| | (0.1383) | (0.1285) | (0.2806) | (0.2831) |
| Observations | 1756 | 2094 | 574 | 491 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

enterprises often wield substantial political influence and can even leverage fiscal influence to directly engage in local governments' political processes (Bischoff et al., 2017). Consequently, in the context of public power influencing capital flow, large enterprises are more likely to receive financial compensation, enabling them to recover more rapidly. However, research has indicated that financial support for large enterprises does not always result in positive recovery effects (Xie et al., 2024). Furthermore, governments often adjust tax burdens to alleviate pressures on enterprises during periods of external uncertainty. In such cases, proactive fiscal policies can enhance SMEs' resilience in coping with societal risks. A volatile market environment also intensifies competition for SMEs, which compels them to accelerate product innovation and improve competitiveness, which ultimately ensures the survival and stability of such enterprises (Pan et al., 2024).

To further explore this dimension, we introduce firm size into our analysis as a key variable to assess whether the impact of internet platforms on commercial innovation differs across firms of various size. We classify the sample into four categories based on the number of employees, encompassing micro and small enterprises (fewer than 10 employees), medium-sized enterprises (10 to 50 employees), large enterprises (50 to 100 employees), and ultralarge enterprises (more than 100 employees), presenting the results in Table 12.

The findings reveal that in micro and small and medium-sized enterprise groups, the coefficient of Internet platforms is statistically significant at the 1% level, indicating that internet platforms have a substantial effect on smaller firms' commercial innovation. In contrast, for large and ultralarge enterprises, the regression coefficients of Internet platforms are insignificant, indicating that the impact of internet platforms on commercial innovation in such firms is less pronounced.

These findings suggest that smaller firms are more likely to be influenced by internet platforms, with a stronger propensity to leverage platforms to accelerate commercial innovation. In contrast, larger firms face more complex constraints and challenges that may hinder their ability to effectively use internet platforms for commercial innovation. Therefore, the results indicate that firm size has a significant influence on determining the degree of internet platforms' influence that on commercial innovation, with smaller firms more readily adopting and benefiting from such digital tools.

Furthermore, as an open innovation ecosystem, internet platforms are an expanding concept that covers technological innovation, integration of industry, R&D fusion, and many forms of data sharing, among other advances (Cao, P, 2024). Internet platforms are diverse in nature,

**Table 13**
Extended analysis: internet platform type.

| Internet platform type | Ad network platforms *Commercial innovation* | Community platforms *Commercial innovation* | Search engine platforms *Commercial innovation* |
|---|---|---|---|
| *Internet platform* | 0.2204 | 0.4332*** | 0.6977*** |
| | (0.1360) | (0.1563) | (0.1679) |
| *dy/dx* | 0.0475 | 0.0876 | 0.1518*** |
| | (0.0293) | (0.0315) | (0.0359) |
| Control variables | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y |
| Pseudo $R^2$ | 0.0390 | 0.0446 | 0.0603 |
| Constant | −1.6094*** | −1.4917*** | −1.6337*** |
| | (0.1238) | (0.1459) | (0.1821) |
| Observations | 2191 | 1652 | 1072 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

encompassing various forms such as ad network platforms (e.g., pop-up advertisements, banners, animations, and videos), community platforms (e.g., forums, Weibo, WeChat, QQ, and embedded advertisements in emails), and search engines (e.g., search engine optimization, ranking algorithms, keyword relevance, and popularity). Therefore, the influence of these different platform types on corporate commercial innovation may vary. To explore these effects, we classify the sample based on the type of internet platform employed by the firm, categorizing them into ad network, community, and search engine platforms. The results of this analysis are presented in Table 13, revealing that the coefficients of Internet platforms in community and search engine platform categories are significantly positive, indicating pronounced and beneficial impact on corporate commercial innovation. In contrast, the coefficient of Internet platforms in the ad network platform category is insignificant, suggesting that the use of ad network platforms does not have a substantial effect on fostering commercial innovation.

These results demonstrate that the use of ad network platforms (i.e., inserting pop-up ads, banners, animations, and videos on various websites) does not effectively generate consumer engagement or feedback, which limits its potential to accelerate the pace of commercial innovation. Conversely, community platforms (e.g., social media applications) and search engine platforms facilitate greater consumer recognition and interaction, expediting the process of commercial innovation. This highlights the importance of considering platform type in terms of the effectiveness of digital marketing strategies in fostering innovation, indicating that firms should prioritize platforms that facilitate direct consumer engagement and feedback such as community-based platforms and search engines to maximize their innovative potential.

Finally, firms' geographical location is a significant factor that

**Table 14**
Extended analysis: regional geographic location.

| Regional location | Eastern *Commercial innovation* | Central *Commercial innovation* | Western *Commercial innovation* |
|---|---|---|---|
| *Internet platform* | 0.5899*** | 0.3403** | 0.2668 |
| | (0.1369) | (0.1328) | (0.2285) |
| *dy/dx* | 0.1283*** | 0.0673*** | 0.0619 |
| | (0.0295) | (0.0262) | (0.0529) |
| Control variables | Y | Y | Y |
| Clustered robust standard errors | Y | Y | Y |
| Pseudo $R^2$ | 0.0595 | 0.0345 | 0.0436 |
| Constant | −1.5021*** | −1.6151*** | −1.8958*** |
| | (0.1181) | (0.1431) | (0.2330) |
| Observations | 1994 | 2167 | 754 |

Note: *, **, and*** indicate significanceat the 10%, 5%, and 1% levels. Robust standard errors are in brackets.

warrants consideration in this study, particularly in the context of China, considering its vast territory and regional economic disparities. Geographic location is likely to influence the outcomes of this study, considering the substantial differences in economic development across China's eastern, central, and western regions. To address this concern, we divide the sample into eastern (coastal areas along the Pacific), central (inland areas), and western (areas bordering Central Asia) regions. This regional division enables a more granular analysis of how geographic and economic factors may interact with the relationship between internet platforms and commercial innovation. The rationale for this segmentation is rooted in the pronounced economic disparities across these regions. Economic power in China exhibits a clear hierarchical structure, with the eastern region possessing the highest economic strength, followed by the central region, and the western region being the least economically developed (Zhao et al., 2024). This stratification provides a framework for us to examine how regional economic conditions may influence the effectiveness of internet platforms in driving firms' commercial innovation.

Table 14 reveals a systemic decline in the significance of the Internet platform coefficient across these regions. Specifically, the positive effect of internet platforms on commercial innovation is most pronounced in the eastern region, followed by the central region, and is weakest in the western region. These findings empirically substantiate the hypothesis that regional economic strength has a pivotal role in mediating the impact of digital platforms on business innovation. In essence, the greater a region's economic development is, the more substantial the influence of internet platforms will be on firms' commercialization and innovation processes. These results demonstrate the significance of considering regional economic factors when examining the role of digital platforms in fostering commercial innovation. The findings indicate that firms operating in economically advanced regions are better positioned to leverage the potential of digital tools for innovation, whereas those in less economically developed regions may face considerable barriers to using these platforms effectively.

## Conclusion and implications

### *Conclusion*

In the contemporary digital era, the internet pervades every aspect of many people's daily lives and work. Discourses concerning how to effectively harness digital technologies to enhance production and lifestyles are indispensable. As pivotal actors in economic activities, enterprises must strategically leverage internet platforms to accelerate growth and innovation. This study examines the impact of internet platforms on corporate commercial innovation, elucidating the profound implications of e-commerce and online sales proliferation on firms' commercial innovation. Our study demonstrates that internet platforms significantly bolster corporate commercial innovation capabilities. This finding remains robust across a variety of methodological tests, encompassing alternative variable measurement techniques, different estimation models, PSM, and IV methods. Examining potential influences from the external environment (market information feedback) and internal corporate dynamics (development motivation), reveals that enhanced corporate development motivation is the primary mechanism through which internet platforms accelerate commercial innovation. While improved market information feedback also accelerates innovation, its impact is relatively less significant and weaker in comparison. Furthermore, we also explore the differential impacts of internet platforms on commercial innovation across various enterprises, considering the impacts of visible (government) and invisible (market) hands. The findings reveal that government support and intervention significantly amplify the benefits of internet platforms, enhancing firms' innovation capabilities and accelerating the pace of commercial innovation. Conversely, enterprises exhibit higher reliance on internet platforms and a greater propensity to expedite innovation through these digital channels in more developed and competitive market environments.

In addition, our extended analysis reveals several interesting conclusions. For instance, the impact of internet platforms on commercial innovation varies significantly across industries and is most pronounced in the retail, manufacturing, and services sectors, and least so in finance and transportation industries. Furthermore, firm size is an important factor that must not be overlooked. Our results demonstrate that internet platforms have the most substantial impact on SMEs' commercial innovation, while the effect on large enterprises is comparatively weaker. This finding provides valuable insights and new perspectives for advancing SMEs' commercial innovation. Additionally, the method and type of internet platform employed by firms also has a crucial influence. Our analysis reveals that using network alliance platforms (e.g., pop-up ads, banners, animations, and videos) does not enhance commercial innovation. In contrast, leveraging community (such as forums, Weibo, WeChat, QQ, and email for embedded advertising) and search engine (through search engine optimization, ranking, and keyword research) platforms significantly contributes to improving commercial innovation capabilities. Finally, we include geographic location in our analysis by dividing China into eastern, central, and western regions. The results indicate that the impact of internet platforms on commercial innovation is strongest in the eastern region, followed by the central region, and weakest in the western region. This conclusion highlights the critical influence of a country's or region's economic strength on shaping the impact of internet platforms on enterprises' innovation. Stronger economic power will elicit a greater the effect of internet platforms on commercial innovation.

Compared with previous research, this study offers three notable contributions.

1) Theoretical advancement: Constructing a comprehensive theoretical framework, this study examines the impact of digital platforms on firms' commercial innovation from perspectives of internal organizational dynamics and external environmental factors. This approach significantly enriches previous theoretical discourse, providing more comprehensive insights into the mechanisms through which digital platforms influence firms' commercial innovation.
2) Integrating institutional perspectives: This study incorporates government (visible hand) and market-driven (invisible hand) forces into the analysis of digital platforms' effects on firms' commercial innovation. By systematically delineating the differences between these two forces, the research offers a granular exploration of their respective influence, broadening the scope of academic inquiry and paving the way for novel future research trajectories.
3) Empirical differentiation: We conduct a nuanced analysis of firm-level heterogeneity by considering firm size, industry classification, platform usage type, and geographical characteristics. The findings reveal the differentiated impact of digital platforms on firms' commercial innovation across diverse contexts. Based on these findings, we propose targeted recommendations to guide firms in leveraging the advantages of digital platforms while aligning with their unique attributes to foster sustainable innovation and growth.

### *Implications*

The onset of the COVID-19 pandemic in 2019 profoundly disrupted global economic activities. Measures such as lockdowns and other public health interventions, although necessary to protect public health, largely curtailed economic activities, adversely affecting production, distribution, and consumption. However, amid these challenges, the pandemic also established unprecedented opportunities for e-commerce and contactless digital transactions. The resulting shift in trade and consumption patterns significantly stimulated the growth of online shopping and services that are dependent on internet platforms. For

enterprises, the strategic use of internet platforms to harness their advantages and accelerate commercial innovation is of paramount importance. Our study demonstrates that firms can leverage internet platforms to expedite product innovation and meet evolving market demand. Therefore, enterprises should prioritize internet platforms, actively monitor consumer feedback, address product deficiencies, and accelerate the pace of product updates to secure long-term growth.

In this process, firms must first identify the organizational attributes of platform services. As technology developers and producers of goods, professional manufacturing and service enterprises must establish deeper partnerships with platform organizers. This involves transitioning from mere platform participants to platform sponsors and technological collaborators to foster agreements on platform architecture control and governance mechanism development around customer relationships (Jovanovic et al., 2022). While the retail sector and small and micro enterprises can leverage platform scale effects to enhance innovation capacities, their limited access to resources and organizational constraints can result in the loss of bargaining power and managerial agency in cooperation with platforms. Consequently, small firms may be marginalized in the value distribution of data resources. To address this, large manufacturing firms with robust production and technological innovation capabilities should collaborate with SMEs. By engaging in the control and decision-making processes regarding platforms' data resources, firms can drive the evolution of digital platforms toward more inclusive and service-oriented models. This will not only strengthen platforms' efficacy in fostering business collaboration but will also promote the development of more open and inclusive digital ecosystems. Second, our findings demonstrate that platforms can accelerate competition between firms through data flow, prompting firms to seek differentiation while also facilitating collaboration. Rapid data exchanges foster interfirm collaboration, which, as numerous studies have suggested, enhances innovation, reduces resource redundancy, and establishes a collaborative platform ecosystem for innovation and R&D (Zhang et al., 2024).

A stable trust mechanism is essential for establishing a seamless network connecting technological development, platform services, and consumer experiences (Danilin et al., 2021). Establishing trust requires the accurate assessment of data value. While there is a broad consensus concerning the value of data, its evaluation remains ambiguous (Mohlmann., 2021). This lack of clarity can result in unequal value distribution between platforms and firms, undermining the trust chain and hindering the establishment of a stable innovation environment. Trust-building also necessitates clear boundaries for data use and access. Without such limitations, power imbalances between platforms and their participants may erode trust, weakening collaborative relationships.

Furthermore, firms that use digital platforms should also actively seek government support to regulate platform usage and prevent unfair competition. As governments often act as both promoters and regulators of digital platforms, they should establish detailed rules and comprehensive standards for platform use to ensure orderly competition among firms. For instance, the Beijing municipal government in China launched a unified city-wide data intellectual property registration platform in 2021, establishing a well-structured system for data ownership and profit distribution, which significantly regulated firms' digital platform use. Beijing also established a public data-sharing mechanism to facilitate interconnectivity between public data and relevant business systems. The local government created dedicated public data zones for key sectors such as finance, healthcare, transportation, and spatial data to promote conditional data openness and socialized applications, ensuring firms' compliance when using digital platforms (Zeng et al., 2023). Governments can also encourage firms to accelerate digital transformation by providing financial subsidies and tax incentives. For example, the Shandong provincial government in China has long strengthened fiscal and tax support to foster platform economy development, introducing numerous tax policies such as R&D expense super deductions, equity incentives, innovation and entrepreneurship support, and small and microenterprise tax relief. These measures incentivize firms to leverage digital platforms for technological innovation. Furthermore, Shandong has promoted the adoption of electronic invoices via digital invoicing platforms, reducing operational costs for platform enterprises while encouraging financial institutions to offer targeted and flexible financial products to support innovation, which has significantly enhanced firms' innovation capabilities (Cong et al., 2022).

Similarly, firms cannot overlook the influence of market forces during the development of the platform economy. Enterprises must be able to expediently adjust strategic decisions in response to market dynamics. Market competition is a vital external driver of corporate development. Firms must innovate products and services based on competitive pressure. Firms can use digital platforms to identify market trends and chart unique developmental pathways and produce differentiated products and/or services by analyzing similar enterprises' offerings. For instance, Pinduoduo, one of China's leading e-commerce giants, leveraged digital platforms in its early stages to differentiate its offerings from competitors such as Taobao and JD.com. By focusing on underserved markets, particularly in lower-tier cities and rural areas, Pinduoduo offered cost-effective products tailored to consumers' needs in these regions. Through innovative approaches like "social fission" and "group-community fission," the company rapidly expanded its user base in these markets, achieving remarkable growth and business success (Shi et al., 2022). Furthermore, consumer feedback is crucial for advancing firms' sustainable development. Firms must prioritize review and responsiveness to customer feedback on their products and services, leveraging digital platforms to track market trends and continuously innovate. For instance, Didi, a leading Chinese ride-hailing service, emphasizes consumer feedback and driver evaluations significantly. By systematically collecting and analyzing platform feedback, Didi has developed a robust feedback and complaint-handling mechanism encompassing consumer complaints, company information verification, trip record analysis, root cause investigation, bilateral communication, and service improvement. This system not only addresses consumers' concerns and enhances satisfaction but also safeguards drivers' rights, maintains operational order, and bolsters the company's reputation and competitiveness in the market (Nyamekye et al., 2021).

Moreover, the use of digital platforms inevitably introduces challenges such as unclear data valuation, power imbalances, and privacy breaches (Li et al., 2021; Sadowski, 2020), which compels us to acknowledge the positive aspects of digital platforms as well as their potential risks. First, while digital platforms excel at collecting and processing vast amounts of data, evaluating the value of these data remains ambiguous. This uncertainty can result in difficulties quantifying data's potential value, introducing data use and transaction disputes. For example, conflicts may arise when firms attempt to leverage these data. Furthermore, digital platforms occupy a pivotal role in the digital economy, wielding significant power and resources. This dominance may foster market monopolies and unfair competition, disrupting normal market operations as more firms integrate into digital platforms and their economic influence continues to grow, expanding their power and resources. This dominance may harm consumers and other enterprises, compromise market fairness, and undermine the competitive environment of the market economy. Finally, the widespread adoption of digital platforms increases the risk of personal privacy breaches, which exposes individuals to economic losses and may also have long-term repercussions on consumers' personal and professional lives. For instance, identity theft could damage a victim's credit history, potentially affecting their access to loans or employment opportunities.

Governments must strengthen data protection regulations to mitigate the potential negative impacts from digital platforms. This includes developing and enforcing stricter standards for data collection, storage, use, and sharing to safeguard personal privacy. Citizens' awareness of data privacy protection should also be enhanced, encouraging the

adoption of measures such as regularly updating passwords and avoiding personal information disclosure. Digital platforms must also implement robust internal governance and data management protocols, establishing stringent data protection mechanisms to ensure user data safety and privacy. External regulatory measures must also be reinforced. Governments and relevant institutions must enhance oversight of digital platforms to ensure compliance with legal standards and prevent the misuse of market dominance and data breaches. For example, the Shanghai local government has focused on building a robust regulatory system for digital platforms, strengthening antimonopoly and antiunfair competition measures, cracking down on black-market transactions, and improving complaint and reporting mechanisms. Shanghai has also emphasized credit system development and encouraged digital platforms to leverage their scale, data, and technological advantages to establish compliance frameworks tailored to their unique characteristics. These frameworks guide platforms to take primary responsibility in areas such as fair competition governance, rule-making, major decision-making, operational transparency, risk identification and management, evaluation and improvement, and innovation-driven development. Shanghai authorities also urge platforms to enhance their compliance management systems, improve oversight, and address platforms with high complaint volumes. Platforms found violating laws are strictly penalized to uphold order in the digital economy market (Mou et al., 2024).

Finally, due to enterprises' significant differences in the size, industry, and regional locations, the strategies and measures adopted by each firm vary considerably. Regarding enterprise size, SMEs stand to benefit significantly from digital platforms, which offer vital business development opportunities. SMEs should take advantage of the digital platform wave to accelerate their digital transformation. For instance, SMEs can establish comprehensive marketing networks by creating official websites to showcase product information, company profiles, and contact details to expand publicity, enhance brand visibility, and foster customer loyalty. They should also adopt diverse content marketing strategies, producing various forms of content (text, images, and videos) centered on user needs and interests to provide valuable information and solutions. Additionally, SMEs can engage in cross-platform collaborations and alliance marketing, partnering with multiple websites and/or forums to publish articles and advertisements and conduct joint marketing campaigns with complementary brands to promote products or services collaboratively.

From an industry perspective, digital platforms have had a profound impact on industries such as manufacturing, services, and retail. Firms in these sectors should quickly adapt to the trend of digital transformation, intensify their use of digital platforms, and leverage these platforms to drive commercial innovation. Firms in these industries can leverage digital platforms to enhance product or service visibility, accelerate innovation in their offerings, and ensure sustainable growth in competitive markets. For industries like finance and transportation, where the impact of digital platforms is relatively less pronounced, enterprises should still recognize the advantages and influence of digital platforms. These firms should actively use digital platforms to enhance innovation capabilities and ensure sustainable development.

From the regional resource perspective, firms located in economically developed regions can leverage digital platforms to make better use of surrounding resources and integrate into regional economic development more effectively. Enterprises in such regions should actively participate in digital platforms to integrate various resources and exploit regional advantages to advance innovative growth. Although firms in economically underdeveloped regions lack the resource and factor advantages of their counterparts in developed areas, digital platforms can transcend spatial and temporal limitations to access more resources. Consequently, these enterprises should actively explore the resources that are now available through digital platforms, establish smoother connections with external regions, and accelerate the pace of product and service innovation.

## Limitations and future research

As with most research, our study has certain limitations that present opportunities for further scholarly exploration. First, although market factors are incorporated into our analysis, the constraints of the manuscript's length and the scope of our sample data limit our ability to consider a wider array of market influences. For instance, employing Porter's Five Forces model could provide deeper insights into how internet platforms reshape industries' competitive dynamics. This approach would allow for a more nuanced understanding of how market competition impacts innovations' costs, velocity, and likelihood of success (Porter., 2008). This could enhance our understanding of how firms can leverage internet platforms to navigate competitive pressure more effectively. Accordingly, future research will seek to refine and extend this analysis, exploring these considerations in greater depth to augment and expand upon this study.

Furthermore, the emergence of internet platforms inherently facilitates greater communication and collaboration between firms, which raises the pressing issue of how to ensure productive cooperation while minimizing conflicts and disputes. However, the limited scope of our current sample restricts our ability to explore this issue comprehensively. In the future, addressing this issue will require a more extensive dataset for deeper analysis, which necessitates expanding the scope of research beyond a single country or region and conducting sample collection across multiple countries and regions worldwide, which undoubtedly represents a challenging task. When conducting research and data collection in different countries, it is essential to fully consider the cultural, religious, and societal differences across nations and ethnic groups, in addition to variations in internet platforms across different countries. To this end, we plan to employ multiple data collection methods such as conducting questionnaire-based interviews with entrepreneurs and managers in various countries to gather data, consulting and downloading information from different websites, and using web-scraping techniques to extract data from news reports. We aim to obtain a more comprehensive and multifaceted dataset by using these diverse approaches. Expanding our sample size and diversifying our data sources will provide a more detailed understanding of the dynamics of interfirm collaboration to enrich and broaden the body of research on the role of internet platforms in facilitating business cooperation and innovation.

Finally, the relationship between internet platforms and corporate commercial innovation transcends a purely economic inquiry, constituting a multifaceted issue that intersects with a variety of disciplines such as economics, management, psychology, and sociology. The research presented in this study is confined to an economic perspective and does not encompass contributions from other fields, lacking a truly interdisciplinary approach. Moving forward, it is imperative to broaden our research framework by adopting interdisciplinary methodologies. For instance, from a psychological perspective, we could investigate the influence of managerial practices and cognition in the context of internet platforms and corporate commercial innovation. From a sociological perspective, we could examine the ethical dilemmas and the digital divides associated with internet platforms. A more expansive and integrated perspective will enable a more comprehensive exploration of the impact of internet platforms on corporate innovation and innovation culture, augmenting the depth and scope of our research and enhancing its practical relevance.

## CRediT authorship contribution statement

**Fang Zhao:** Supervision, Conceptualization. **Guoliang Jiang:** Formal analysis, Data curation. **Yi Xu:** Methodology, Investigation, Conceptualization. **Wanying Ma:** Writing – review & editing, Visualization.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships thatcould have appeared to influence the work reported in this paper.

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