

Cultivating 'followers' or 'competitor'? - A study of innovation disclosure by technology leaders and their innovation ecosystem leadership

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Abstract: From the perspective of gaining and maintaining innovation ecosystem leadership, innovation disclosure by technology leaders faces the dual effects of cultivating "followers" and strengthening "competitors". Therefore, it faces the decision dilemma of whether to strengthen innovation disclosure to enhance ecosystem leadership or weaken disclosure to prevent imitation by competitors, forming a new 'leader paradox'. This paper explores the relationship between technological leaders' innovation information disclosure and their innovation ecosystem leadership from the perspective of the paradox. Through an in-depth analysis of data from 2016-2022 A-share listed leading manufacturing enterprises, the research findings show that: (1) technology leader innovation information disclosure will trigger the dual outcomes of "followers grow" and "competitors challenge", resulting in a U-shaped relationship between innovation information disclosure and innovation ecosystems leadership; (2) various driving factors, such as internal technological distance and external government subsidies, will change the intensity of the role of information disclosure, flattening the U-shaped relationship and causing the inflection point to occur earlier. (3) Technology leaders have a strategic behaviour of enhanced innovation disclosure to strengthen their leadership in innovation ecosystems, but they need a stronger innovation atmosphere among their followers to ensure the effectiveness of this strategy. This study provides useful insights and empirical evidence for technology leaders on how to balance the risks and benefits of innovation disclosure in the pursuit of innovation ecosystem leadership, and promote the healthy and stable development of innovation ecosystems.

1. Introduction

Innovation ecosystems have become a research hotspot in the last two decades (Altman et al., 2022; Jacobides et al., 2024; Shen et al., 2024). An innovation ecosystem is defined as the evolving set of actors, activities and artefacts, as well as the institutions and relationships, including both complementary and competitive relationships (Granstrand & Holgersson, 2020; Granstrand, 2024). These complex relationships within the ecosystem require a center to coordinate and guide the orderly activities of the innovation ecosystem (Autio, 2022), which is often a deliberate and purposeful action of the leader within the innovation ecosystem (Dhanaraj & Parkhe, 2006; Iansiti & Levien, 2004; Iyer et al., 2006; Shen et al., 2024), through strategic planning and value co-creation, coordinating the integration of various participants around a common

value proposition, establishing a complementary symbiotic cooperative relationship with followers, responsibly managing the competitive relationship with competitors, thereby optimising resource allocation and promoting ecosystem development and other possible forms of collaborative development (Sahasranamam et al., 2024; Pushpanathan & Elmquist, 2022; Burford et al., 2022).

However, for technology leaders, the process of pursuing innovation ecosystem leadership is fraught with high levels of uncertainty, which is particularly evident in their attempts to cultivate leadership through more open innovation information disclosure. On the one hand, appropriate innovation information disclosure is conducive to cultivating followers' capabilities and enhancing mutual trust (Reiter et al., 2024), and by empowering followers, it enhances the leader's innovation ecosystems leadership (Shi et al., 2024). On the other hand, excessive disclosure of innovation information may also allow competitors to capture key information, enhance their competitiveness, and weaken the innovation ecosystems leadership of the leader (Jacobides et al., 2024), thus creating a "leader paradox" of cultivating "competitors" or "followers". Therefore, it is necessary to further explore the multiple effects of technological leaders' innovation information disclosure on knowledge spillovers, reputation cultivation, and competitors' growth in the innovation ecosystem under the goal of pursuing leadership. It is also necessary to determine its effectiveness in creating and enhancing leadership in innovation ecosystems, and then to explore possible measures to enhance this effectiveness.

Existing literature suggests that technology leaders can achieve leadership and build innovation ecosystems by mutually empowering themselves and their followers. Specifically, building modular technology platforms (Pushpanathan & Elmquist, 2022), building complementary follower layers based on uncertainty (Reiter et al., 2024), and enhancing value co-creation with followers (Shi et al., 2024) are effective ways to achieve this goal, as well as pointing to the conflicting situations that technology leaders may face when building and operating good innovation ecosystems (Song et al., 2024). However, there is still a lack of empirical evidence on the strategic dilemmas and paradoxes of choice they face in acquiring innovation ecosystem

leadership, as well as the internal contradictions and complex impact mechanisms behind these dilemmas and paradoxes.

At the level of corporate strategy, information disclosure is seen as a key bridge for technology leaders to communicate with the innovation ecosystem. The construction of the innovation value chain, the company's perception of the development direction of technology, and the company's judgement of the maturity and development form of technology, etc., all of which are contained in innovation information, are important proprietary information. Therefore, technology leaders will show hesitation and doubt in making decisions about the breadth and depth of innovation information disclosure, which is also a typical form of dilemma or paradox of strategic decision-making for leaders. This 'leader's dilemma' is exacerbated in the pursuit of innovation ecosystem leadership. On the one hand, extensive and appropriate innovation disclosure is conducive to enhancing the firm's reputation for technological innovation and strengthening its leadership over followers in the ecosystem; on the other hand, the firm may also face the risk of disclosing key innovation information that cultivates the catch-up capabilities of competitors in the ecosystem and weakens its leadership and dominance in the innovation ecosystem. In other words, the disclosure of innovation information by a technology leader faces the dual effect of cultivating both "followers" and "competitors", which reinforces the "leader's dilemma" in the decision to disclose innovation information. For example, Tesla, a leader in new energy vehicles, is a typical case of innovation disclosure through open source code and public patents. On the one hand, disclosure fosters the growth of followers, allowing them to quickly integrate into Tesla's technology platform for collaborative development. On the other hand, the disclosed source code can also cultivate competitors, and there is a risk of being overtaken by newcomers.

In light of the aforementioned background, the present paper aims to explore in depth how leaders can enhance their leadership in innovation ecosystems during the process of innovation disclosure. The research is based on the identification of leaders in innovation ecosystems and a quantitative assessment of their innovation disclosure and innovation ecosystems leadership. The study places particular emphasis on the

decision-making challenges encountered by companies from the perspective of the leader paradox and their impact mechanisms, while also exploring potential avenues for mitigating the adverse effects of innovation disclosure or circumventing decision-making dilemmas. The decision to base the study on China is anchored in several key factors. Firstly, the manufacturing sector of the Chinese economy is considered fundamental to the nation's overall economic structure. As demonstrated by data from the fifth economic census of China (2024), the nation's manufacturing industry accounts for approximately 30% of the global market share, a position it has held for 15 uninterrupted years. However, the manufacturing industry in China is still confronted with the challenge of its large-scale economy not being accompanied by comparable strength. This disparity is particularly pronounced when compared to developed economies such as the G7. Given the sheer magnitude of China's manufacturing sector, the study of its innovation ecosystem and the challenges faced by leaders in attaining leadership is not only universally relevant but also of paramount importance in propelling China's manufacturing industry towards high-end status. The insights derived from this study can thus serve as a valuable reference point for leaders in the innovation ecosystems of other nations. Secondly, China's manufacturing leaders are highly representative. Through their guidance and exemplary role, these leaders can promote the growth of followers in the ecosystem, while maintaining the stability and prosperity of the ecosystem through interactions with competitors (Yu et al., 2024). Therefore, studying the 'leader's dilemma' faced by these companies and finding solutions not only has guiding significance for China's manufacturing industry, but also provides valuable experience for other countries.

This study utilises the comprehensive full-text database of leading manufacturing enterprises on the A-share market from 2016 to 2022, with the objective of investigating the correlation between the innovation information disclosure of technology leaders and their innovation ecosystems leadership. The exploration is informed by the dual effects of guiding 'competitor challenges' and 'follower growth' in innovation information disclosure. The study also explores the possible moderating effects of technological distance advantages and external government subsidies, as well as the effectiveness of

strategies such as reinforced or exaggerated innovation disclosure by technology leaders in solving decision dilemmas.

The marginal contributions of this paper are as follows: First, the "leader paradox" is re-analysed from the perspective of the relationship between innovation disclosure and innovation ecosystem leadership in technology leaders, and the specific forms and possible coping strategies of the leader's decision dilemma in this scenario are explored, enriching the relevant research on the leader decision paradox.

Second, against the backdrop of the era of strengthening the status of enterprises as the main body of innovation, the theoretical mechanism of the formation of technology leaders is enriched and expanded from the perspective of enhancing innovation ecosystems, and expands the theoretical mechanism research on the formation of technology leaders from the perspective of enhancing innovation ecosystem leadership. It provides a useful exploration for the construction of innovation ecosystems and the theory of enhancing leadership.

Third, with the result of enhancing the leadership of technology leaders in innovation ecosystems, this paper explores the difference in the role of innovation information disclosure under the absence of strategic interference and the presence of strategic interference, and expands the research on the impact of information disclosure, especially innovation information disclosure, on firms' innovation objectives.

2. Literature review and theoretical analysis

2.1 Literature review

The term 'innovation ecosystem' is defined as a unique environment composed of heterogeneous partners at different levels that are interdependent and coordinated. These entities collaborate to achieve a shared value proposition and ecosystem blueprint (Shen et al., 2024). The ecosystem's constituent entities encompass leaders, industrial partners, financial institutions, research institutes, universities, and customers, amongst others (Su et al., 2018; Dedehayir et al., 2018). These entities engage in activities such as competition and cooperation, collectively aiming to create value and actualise the value proposition of the innovation ecosystem (Chesbrough et al., 2014). Technology leaders within the innovation ecosystem play a vital role. They fulfil a dual role, promoting the healthy development of the ecosystem and the integrated innovation of the industrial chain, whilst also providing a strong driving force for exploring new opportunities by promoting the continuous integration and restructuring of knowledge among the various entities (Dedehayir et al., 2018; Shen et al., 2024). However, the development of such innovation ecosystems is invariably accompanied by a series of challenges, including institutional uncertainty, dynamic environmental changes, and information asymmetry (Lingens et al., 2021; Sahasranamam et al., 2024). In such circumstances, technology leaders must assume the role of ecosystem leadership (Shen et al., 2024), coordinating the development of the innovation ecosystem and elucidating its value proposition and shared vision (Reiter et al., 2024). In addition, leaders must exercise ecosystem leadership to build sufficient trust within the ecosystem, continuously coordinate to ensure that the value is reasonably distributed and created among the entities in the innovation ecosystem (Majchrzak et al., 2023), and continue to motivate other entities to follow their pace and jointly promote the prosperity and development of the innovation ecosystem (Foss et al., 2023).

Existing research on the innovation ecosystem leadership is divided into two main schools of thought: the first being that innovation ecosystem leadership is a capability, and the second being that technology leader leadership is an activity. Schreieck et al

(2021) posit that innovation ecosystem leadership is a capability that focuses on relationships, and that technology leaders need to achieve a balance between co-creation and sharing of value within the innovation ecosystem. In contrast, Cennamo C et al (2022) propose a definition of innovation ecosystem leadership as a series of processes designed to promote collaborative activities among partners, thereby enhancing the value of the entire ecosystem. Foss et al (2023) posit that the leadership of technology leaders is dynamic based on transaction costs and economics, which is manifested in: promoting the formation of a common vision (perception ability), guiding members to make specific investments in the ecosystem (leadership ability), and participating in solving specific problems to create and position stability (reconfiguration/transformation ability). Shen et al (2024) propose that the leadership of technology leaders focuses on three dimensions: ecosystem strategy design, ecosystem partnerships, and ecosystem resource integration. Notwithstanding the ongoing debate surrounding the nature of innovation ecosystem leadership as either a capability or an activity, there is a prevailing emphasis on the actions of leaders within the ecosystem. In light of these diverse perspectives, this study proposes a synthesis of these viewpoints, while also drawing upon the prevailing practices of innovation ecosystem leadership within the Chinese ecosystem leader's practice. The proposed synthesis asserts that innovation ecosystem leadership is manifest in three key domains: technological innovation leadership, industrial chain integration, and the creation of target markets. The subsequent empirical analysis examines innovation ecosystem leadership from the above three dimensions.

Specifically, ecosystem leaders assume a pioneering role in technological innovation and drive continuous technological and industrial progress within the ecosystem through substantial investment in research and development and the deployment of advanced technological capabilities (Institute of Industrial Economics of CASS & Qu, 2022). Secondly, technology leaders facilitate the optimal allocation of resources and dynamic adjustment of the industrial chain structure in collaboration with other ecosystem participants, thereby promoting industrial innovation and value co-creation, and ensuring the maximisation of ecosystem common interests (Zhang &

Duan, 2023). Finally, the leading enterprise leverages its dominant market position to enhance its influence within the ecosystem by establishing technical standards and specifications (Liu et al., 2019). This completes the creation of the target market and the governance of the innovation ecosystem, thereby shaping the development trajectory of the integrated ecosystem. A prime example of this phenomenon is BYD, a company that has led in technological innovation, launching such advanced technologies as the original blade battery, DM-i super hybrid, and e-platform 3.0. These technologies continue to drive technological progress in the innovation ecosystem. Concurrently, BYD's strategic decision to vertically integrate the industrial chain has enabled the establishment of its distinctive core competitiveness. This, in turn, has contributed to the advancement and sustained leadership position of the company in terms of market share. Furthermore, BYD's commitment to effective governance and leadership within its ecosystem has been instrumental in the consistent establishment of technical standards.

2.2 innovation information disclosure and innovation ecosystems leadership

Technology leaders frequently occupy a central position within the ecosystem, and their information disclosure behaviour is often closely monitored and meticulously analysed by other ecosystem members. Competitors are keen to challenge the leader's position and compete with it for innovation ecosystem leadership. Conversely, followers aspire to comprehend the forefront of emerging technologies and acquire advanced technical expertise to benefit from the leader's innovative information disclosure. This scenario places the leader in a multifaceted position, requiring it to address the challenges posed by competitors while also catering to the growth of followers.

For the competitors of the leading enterprise, the disclosure of innovation information will have a 'competitor challenge effect'. The disclosure of innovation information by the leading enterprise carries inherent risks, including the potential for information spillovers and the leakage of its own innovation information to competitors

(Whittington et al., 2016). This dynamic may potentially diminish the financial burden associated with competitors emulating technological advancements, thereby empowering them to formulate response strategies, such as strategic imitation or strategic defence (Wang et al., 2024; Kankanhalli et al., 2024). This dynamic has the potential to result in the imitation or even surpassing of the leading enterprise's innovation achievements by competitors, thereby reducing their own uncertainty and risk in the innovation process. This phenomenon can facilitate a rapid market entry at a reduced cost, thereby challenging the market position of the leader and weakening its leadership of the innovation ecosystem. This phenomenon can be conceptualised as a gradual weakening of the leader's influence within the industrial chain, prompting partners to re-evaluate their cooperative relationships with the leader and even seek alternatives from competitors offering more competitive solutions. This, in turn, can weaken the leader's industrial chain integration capabilities and negatively impact innovation ecosystem leadership. Consequently, the disclosure of innovation by leading enterprises will result in an overall upward trend in the 'competitor challenge effect' curve.

Conversely, followers of leading enterprises stand to benefit from a 'follower growth effect' through such disclosures. This is due to the fact that the disclosure of innovation by leading enterprises assists in addressing the issue of 'information asymmetry', enables them to showcase their level of innovation, and demonstrates the future development potential of the enterprise (Wang et al., 2024; Kankanhalli et al., 2024), thereby enabling followers to gain insight into the innovation practices of leading enterprises. This phenomenon is not merely a reflection of the leader's technological prowess, but also serves to facilitate the acquisition of advanced knowledge by followers through the demonstration of cutting-edge technology. Furthermore, it fosters the establishment of cooperative relationships between followers and the leader, thereby nurturing and enhancing the growth prospects of both parties within the innovation ecosystem. This dynamic process gradually stabilises the technological trajectory of the followers, thereby promoting the leader's integration into the industrial chain and further enhancing its market position. Consequently, this

contributes positively to innovation ecosystem leadership. Consequently, the leader's innovation disclosure will result in an overall upward trend in the 'follower growth effect' curve.

In summary, the disclosure of innovation information by leading enterprises will have a 'challenger effect' and a 'follower growth effect', which will interactively affect the leading enterprise's innovation ecosystem leadership. Furthermore, the sensitivity levels of competitors and followers to information vary (Whittington et al., 2016; Zhang et al., 2023). Competitors and leading enterprises exhibit similarities in terms of organisational characteristics, product services and market environment. However, to surpass leading enterprises, competitors typically demonstrate heightened sensitivity, are more responsive to market information and exhibit accelerated responses (Wang & Guo, 2024). In contrast, followers frequently require a more substantial and diverse array of information resources to comprehensively comprehend and embrace the leader's innovative practices (Alexy et al., 2018). This observation underscores the notion that the disclosure of innovations will precipitate the 'competitor challenge effect' prior to the manifestation of the 'follower growth effect', thereby exerting an influence on the leadership of innovation ecosystems.

Specifically, in circumstances where the level of innovation information disclosure is minimal, competitors respond expeditiously based on the disclosed information, learning to imitate and even surpass the innovations of the leader. This, in turn, challenges the leader's market position and technological leadership, and weakens the industry chain's right to speak and its ability to integrate the chain. This phenomenon, known as the 'competitor challenge effect', reaches its zenith at this juncture. For followers, inadequate disclosure of the leader's innovation information may give rise to questions regarding the leader's innovation capabilities and transparency. This may, in turn, affect the leader's technological leadership, reduce the leader's propensity to cooperate with followers, and consequently impact the leader's ability to nurture followers. This, in turn, results in the diminution of the follower growth effect. Consequently, when the disclosure of innovative information is inadequate, the curve of the 'competitor challenge effect' becomes more pronounced, while the curve of the

'follower learning effect' becomes less precipitous, resulting in a downward trend in overall innovation ecosystem leadership.

Conversely, when the level of disclosure of innovative information is elevated, it functions as a 'weapon' that significantly deters competitors (Wang et al., 2024). By strategically disclosing sufficient innovation information, the leading enterprise conveys its technological leadership and cost advantages, influencing the incumbent competitors' product pricing and production decisions (Zhang et al., 2023). Furthermore, it is evident that such actions serve to communicate to competitors that mere imitation and learning are inadequate to challenge the leading enterprise's technological leadership. Concurrently, the leading enterprise's substantial production capacity hinders competitors from competing for a position within the industry chain, thereby weakening the leading enterprise's market position and industry chain integration capabilities. In this context, the impact of competitor challenges is deemed negligible. Conversely, adequate disclosure of innovation information by the leader will promote knowledge sharing among followers, enabling them to fully absorb the leader's advanced knowledge and thereby strengthen the leader's technological leadership. This virtuous cycle enhances not only the technological capabilities of followers within the ecosystem, but also enables the leader to achieve its strategic objective of anchoring the followers' technological trajectory. This, in turn, has the effect of further strengthening the leader's industrial chain integration and market position. Concurrently, the 'follower growth effect' is found to be relatively high. This phenomenon occurs because, as the level of innovation disclosure gradually becomes sufficient, the critical point is exceeded, and the curve of the 'competitor challenge effect' becomes flatter, whilst the curve of the 'follower growth effect' becomes steeper. The collective tendency of innovation ecosystem leadership is thus predicted to manifest an upward trend (refer to Figure 1 for the detailed mechanisms underlying these phenomena).

In summary, innovation disclosure will lead to an interaction between the 'competitor challenge effect' and the 'follower growth effect', causing the innovation ecosystem leadership to first decrease and then increase, showing a U-shaped trend. The paper thus puts forward the following hypothesis:

H1: The innovation information disclosure of keystone firms follows a U-shaped relationship with innovation ecosystem leadership, i.e., it first decreases and then increases.

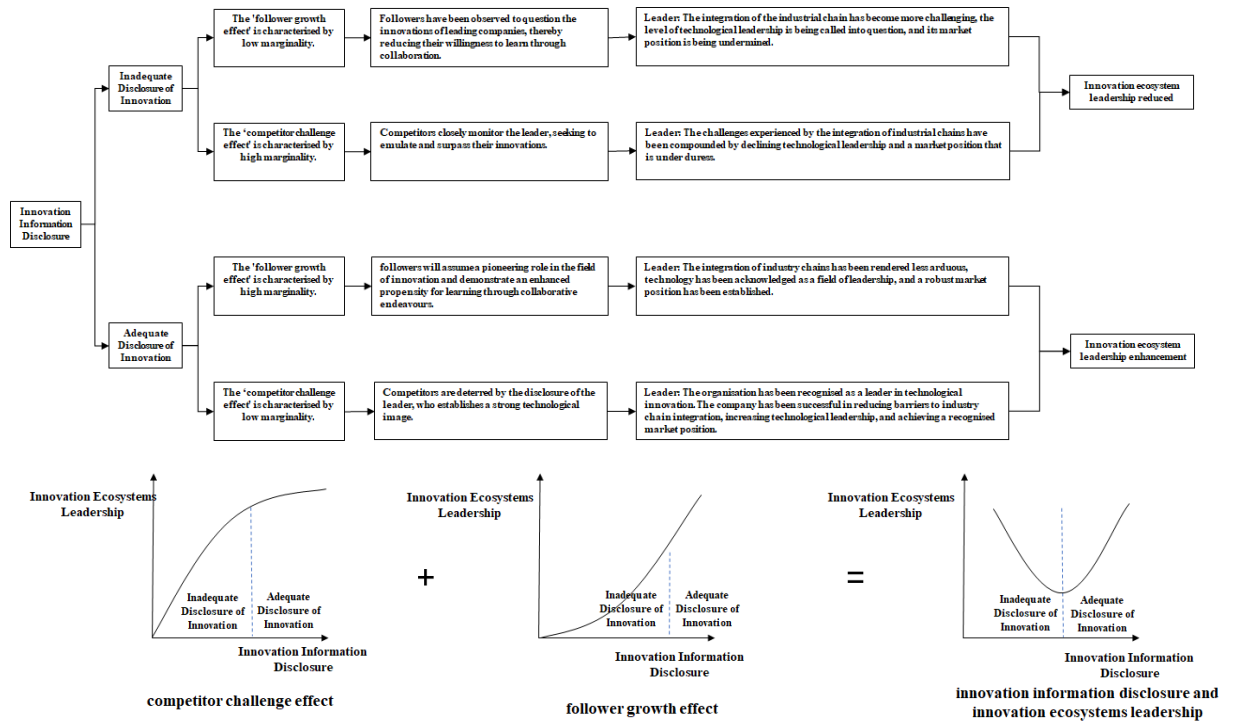


Figure 1 Mechanism of innovation disclosure and innovation ecosystem leadership

2.3 The Impact of Technological Distance

Technology distance is defined as the disparity in fundamental technological capabilities between technology leaders and other participants in the innovation ecosystem (Zhu et al., 2021; Kok et al., 2020). A significant technological distance gap suggests that the leader possesses a comparative technological advantage, thereby providing the ecosystem with greater opportunities to acquire new technological knowledge in unfamiliar domains, generate technological spillovers (Zhu et al., 2021), and promote more profound knowledge restructuring activities (Rosenkopf & Almeida, 2003).

In the context of technological innovation, followers encounter challenges in attaining the technological expectations of their ecosystem when the technological distance between technology leaders is not considerable. This is due to the fact that

leaders' innovation disclosures are not well aligned with the ecosystem's technological expectations, thereby restricting the absorption and improvement of innovation capability among followers (Nambisan, 2013). This suggests that the initial stage of technology leader innovation information disclosure has a relatively weak effect on follower growth. Conversely, as the technological distance between the Leader and the Follower increases, the initial innovation disclosure of the Leader assumes greater significance, effectively capturing the attention of followers and fostering trust. For those followers who aspire to advance their own expertise, the assimilation of emerging technologies as elucidated within the innovation disclosures of leaders has been demonstrated to facilitate the transcendence of one's initial knowledge and competencies (Nambisan, 2013), thereby augmenting the technological leadership of the aforementioned leaders. By targeting the technological path of the follower, the leader strengthens its own industrial chain integration capabilities and further consolidates its leading position in the market. The initial 'follower growth effect' is therefore hypothesised to have a high marginal effect. However, most studies find that a significant increase in innovation disclosure leads to 'information overload' for followers (Impink et al., 2022; Hellman et al., 2018; Chapman et al., 2019; Saha et al., 2019), especially when the technological distance is large. After the leading firm's innovation information disclosure reaches a certain threshold, the follower faces an excess of information about the new technology, which leads to a marginal decrease in productivity growth and performance levels (Jackson & Farzaneh, 2012). The marginal growth of the "follower growth effect" decreases, i.e. after the disclosure of innovation information exceeds a certain level, the marginal "follower growth effect" gradually decreases.

In the context of technological competition, the impact of the technology leader's innovation disclosure on the follower's challenge effect remains constant when the technological distance between the leader and the follower is not excessively pronounced. Conversely, as the technological distance between the technology leader and the competitor increases, the competitor's motivation to learn from and imitate the technology leader's innovation disclosure also increases. In instances where the

technology leader does not disclose sufficient information about its innovations, the leader's substantial technological barriers impede competitors from surpassing them through mere imitation, giving rise to a comparatively gentle early-stage competitor challenge curve. Conversely, as the level of innovation information disclosure rises, the risk of technology spillovers concomitantly increases. Competitors are able to draw insights from the adequate innovation information disclosure of the technology leader, thereby challenging the technology leader's leadership of their innovation ecosystem. This dynamic results in a more precipitous competitor challenge curve at the current juncture.

In summary, when the technological distance is significant, the early challenger effect of the leading enterprise's innovation disclosure is mild. However, once the disclosure threshold is met, the competitor challenge effect curve becomes more precipitous, while the early follower growth effect exhibits a more gradual decline. The interplay between these two factors gives rise to a more gentle U-shaped relationship between the leading enterprise's innovation information disclosure and its dominance in the innovation ecosystem. The specific mechanism is illustrated in Figure 2. The following hypothesis is thus proposed by this paper:

H2: Technological distance will gradually smooth the U-shaped relationship between leader's innovation disclosures and innovation ecosystem leadership.

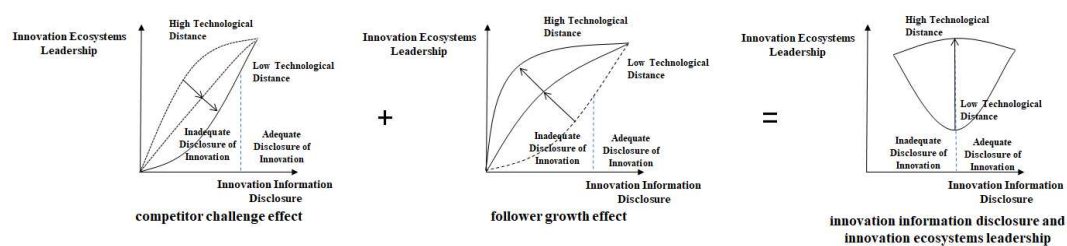


Figure 2 Technological distance moderates the relationship between innovation disclosure and innovation ecosystem leadership

2.4 The Impact of Government Subsidies

Leaders are often at the forefront of innovation, which implies huge investments and research and development costs (Antonioli et al., 2017). As an important form of

government financial support, government subsidies can alleviate resource constraints on firm innovation (Luo et al., 2021). Government subsidies can be defined as cash payments and intermediate goods and services provided freely or at nominal prices by governments to specific producers (Robinson, 1967). The existence of a phenomenon known as the "certification effect" has been demonstrated. This effect indicates the higher quality of firms that are subject to government certification. In addition, the existence of a phenomenon known as the "endorsement effect" has been demonstrated. This effect is indicative of the fact that government certification serves as a guarantee of the quality of the firms in question (Yan & Li, 2018). Specifically, government subsidies have been shown to send a quality signal to the innovation ecosystem and help leaders to be better recognised within the ecosystem (Yan & Li, 2018).

For followers, government endorsement signifies that the research and innovation activities of leading companies possess potential social value, thereby disseminating a positive signal for cooperation and inspiring other entities within the innovation ecosystem to engage in knowledge exchange (Hillman, 2005; Pan et al., 2024; Yu et al., 2024). The acquisition of knowledge from the disclosure of innovation information has been demonstrated to enhance the technological leadership, improve the willingness of followers to cooperate, and improve the industry chain integration capability and market position of leaders. In the absence of substantial government subsidies, the effect of innovations disclosed by technology leaders on the challenges faced by their followers remains constant. Conversely, in instances where government subsidies are augmented, the marginal effect of the initial disclosure of innovations by technology leaders on the learning effect of followers is potentiated. This is due to the fact that the endorsement of the leader by the government signifies the enterprise's robust scientific research capabilities, consequently resulting in a more precipitous initial learning curve for followers. However, as posited by the information overload theory, once the leader has divulged a sufficient amount of information related to innovation, it may cause the followers to adopt the incorrect technical trajectory. This may result in a decline in followers' productivity and performance levels due to the excessive amount of available information (Jackson & Farzaneh, 2012). Therefore, government policies contribute to

fostering the development of the remanufacturing industry (Esenduran et al., 2025). In summary, once a certain level of innovation information disclosure is reached, the marginal effect of followers' growth will gradually decline.

The impact of government subsidies on leaders is twofold. Firstly, government subsidies can be a catalyst for innovation (Wei and Liu, 2015; Howell, 2017; Shao et al., 2021; Wu et al., 2022). Secondly, they can stimulate R&D spending (Greco et al., 2017; Hu & Deng, 2019; Zhang & Chen, 2019; Wu et al., 2022), and increase their R&D intensity (Liu et al., 2016; Jiang et al., 2018; Wu et al., 2022), helping leading firms to consolidate their technological advantages while the innovation ecosystem flourishes. Conversely, government subsidies have been shown to engender dependency and divert leaders' resources (Rhee & Leonardi, 2018; Yi et al., 2021). The net effect of these two factors on the relationship between innovation information disclosure and ecological leadership is moderated. Specifically, government subsidies can facilitate the establishment of unique competitive advantages and market barriers by leaders. Consequently, while the initial innovation disclosure by leaders engenders strong incentives for imitation and learning by competitors, the absence of government support results in a relatively flat initial competitor challenge curve. As the degree of disclosure of innovation continues to increase, institutional pressures resulting from government policy support may lead to institutional constraints that divert the Leader's resources, thereby creating conflicts between the Leader and followers. This, in turn, can result in path dependence in innovation by the Leader, leading to duplication and redundancy in knowledge development. Consequently, competitors are presented with the opportunity to challenge the Leader by adopting strategic imitative or defensive measures, thereby rendering the competitor challenge curve steeper.

In summary, when government subsidies are high, the early competitor challenge effect of the leading enterprise's innovation disclosure is mild. However, once a certain threshold is attained, the competitor challenge effect curve experiences an upward shift, while the early follower learning effect curve becomes more pronounced. Subsequently, at a certain level, the follower learning effect curve experiences a decline, leading to a more gentle U-shaped relationship between the leading enterprise's innovation

information disclosure and innovation ecosystem leadership. The underlying mechanism is illustrated in Figure 3. In light of these observations, this paper puts forward the following hypothesis:

H3: Government subsidies will gradually flatten the U-shaped relationship between the leading enterprise's innovation disclosure and innovation ecosystem leadership.

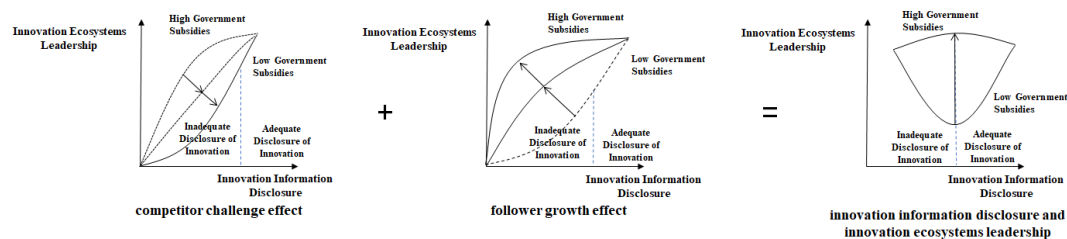


Figure 3 Government subsidies and the moderating effect of innovation disclosure and innovation ecosystem leadership

2.5 Theoretical Framework

Based on the above analysis, the theoretical model constructed in this paper is represented in Figure 4. This study will first explore the U-shaped relationship between the main effect of innovation disclosures and innovation ecosystem leadership. In examining the moderating effects, the study will investigate how different types of driving factors influence this relationship. Specifically, the technological distance of leaders will be treated as an internal driving factor, while government subsidies will be considered as an external driving factor, with the aim of exploring how these factors moderate the relationship between innovation disclosures and innovation ecosystem leadership.

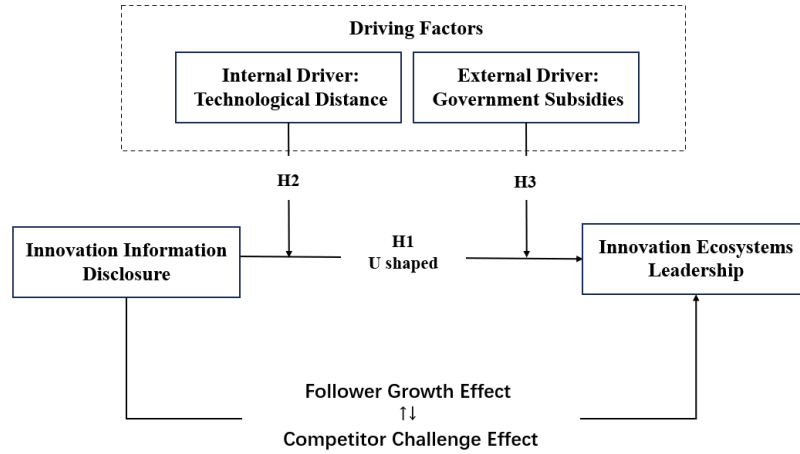


Figure 4 Theoretical Model

3. Data, variables and model

3.1 Data and sample

The study commences with the utilisation of Python-based web scraping techniques to extract data on A-share listed companies that are recognised as "leading manufacturing enterprises" across provinces and regions in China. Manufacturing, as a fundamental industry sector, is a major driver of China's pioneering innovation, significantly influencing the transformation and upgrading of China's economic structure. Furthermore, the leading enterprises are able to guide and demonstrate to other enterprises in the innovation ecosystem, thereby promoting the overall innovation level of the innovation ecosystem (Yu et al., 2024).

Given that the "leading manufacturing enterprises" designation commenced in 2016, the study selects a time window spanning **2016 to 2022**. Firm-level data are sourced from the CSMAR (China Stock Market and Accounting Research) and Wind databases. To ensure the robustness of the analysis, the original data underwent the following treatments: (1) Remove samples of ST within the sample period; (2) Remove samples with missing key variables; (3) Remove non-high-tech industries; (4) In order to reduce the impact of outliers, this paper applies the process of winsorising to all continuous variables at the 1% upper and lower levels. After the above processing, a total of 723 leaders were obtained, for a total of 3,665 technology leaders – annual

observed values.

3.2 Variables

3.2.1 Innovation Ecosystem Leadership

(1) Innovation ecosystem leadership: This paper uses principal component analysis to calculate innovation ecosystems leadership, introducing the three variables of industrial chain integration, technology leadership and market competitive position for comprehensive calculation. The first and second principal components are finally extracted, referred to as variables to measure innovation ecosystem leadership, and these two principal components have a cumulative variance interpretation rate of 72%, relatively comprehensively covering the information of the above three indicators.

① Industrial Chain Integration

Drawing on the research of Zhang and Duan (2023), this paper defines a leader's industrial chain integration level as the firm's ability to carry out timely and optimal resource allocation and structural adjustment among various actors in the industrial chain. This capability is the key to promoting industrial innovation and achieving value co-creation. It is measured as the product of the specialisation of enterprise functions and the efficiency of supply chain competition.

The first step is to measure the degree of specialisation of the leader. The level of vertical integration of the enterprise is measured by the value-added approach (Li & Tang, 2010; Zhang & Tong, 2021), which measures the overall situation of the enterprise covering the upstream or downstream of the industrial chain. The formula is as follows:

$$VAS = \frac{\text{Value added} - \text{Net profit after tax} + \text{Normal profit}}{\text{Operating income} - \text{Net profit after tax} + \text{Normal profit}}$$

Of these, operating income is the difference between total operating income and other operating income; net profit after tax is the difference between net profit and taxes and surcharges; normal profit is operating income less operating expenses less (selling

expenses + administrative expenses + financial expenses); operating expenses are the difference between total operating expenses and other expenses; value added = operating income + net inventory - (cash paid for goods and services + net advance payments + net notes payable + net trade payables) / (1 + VAT on purchases).

In addition, vertical integration and division of labour are interrelated indicators. To ensure the validity of the data, the level of vertical integration is between [0,1], and the abnormal values of the samples that are not in the interval are deleted. Therefore, the division of labour of the enterprises is as follows:

$$VSI = 1 - VAS$$

The second step is to measure the degree of supply chain integration. Supply chain efficiency is used to represent the level of integration of the company and inventory turnover is used as a proxy:

$$ITR = \frac{\text{Cost of goods sold}}{\text{Average net stock}}$$

The average net stock is equal to (opening net stock + closing net stock) / 2.

The third step is to measure the degree of industrial chain integration, which is the product of the degree of professional division of labour and the degree of supply chain integration.

$$ICC = VSI * ITR$$

② Industrial Chain Integration

Technology leadership. This paper uses the number of citations of a firm's patents as a measure of technological leadership. The definition of the variable $IC_{i,t}$ is the total number of citations of the patents of company i and its parent company and subsidiaries in year t . In order to reduce the endogeneity of the data, the logarithm of the number of patent citations + 1 is used as a measure of technological leadership, i.e. $IC_{i,t}$ is the number of citations of granted patents, in order to assess the leadership and influence of companies in the field of technological innovation.

③ Market competitive position

This paper makes reference to the studies of Li et al. (2019) and Bessonova & Gonchar (2019), and employs the Herfindahl-Hirschman Index to represent the relative

market position of enterprises. It is posited that the larger the MP index, the lower the market competition for the enterprise's products and the stronger the market advantage. The precise calculation is outlined in Equation (5).

$$MP = (\frac{X_{i,t}}{X})^2$$

In this equation, X_i represents the total operating revenue of enterprise i in the t^{th} year, and X is the sum of the annual operating revenue of all enterprises in the industry.

$$X = \sum_i^n X_{i,t}$$

3.2.2 Innovation Information Disclosure

The present article employs a three-step methodology to assess the extent of innovation information disclosure by firms.

Firstly, a set of seed words related to innovation is identified. The seed words identified for this purpose are 'technological innovation', 'research', 'development', 'R&D', 'patent' and 'invention'.

The second step involves conducting a textual analysis of the annual report. A text analysis of the annual reports of listed companies was carried out using the Word2vec similar word algorithm of the neural network. The vocabulary was expanded based on the identified seed words, and a set of 401 keywords related to innovation information was finally determined.

The third step in the methodology is to construct an innovation information disclosure index. The innovation information disclosure index is calculated using the formula in equation (7).

$$Inno_Disc = \frac{Frequency\ of\ Innovation\ Keywords\ in\ Re\ port}{Total\ Words\ in\ Re\ port}$$

Concurrently, the index is multiplied by 100 for processing, thereby ensuring a clearer and more direct representation of the level of corporate innovation information disclosure; higher values indicate higher levels of innovation disclosure.

3.2.3 Moderating Variables

The moderating variables in this paper are drivers, namely internal driver technological distance (TD) and external driver government subsidies (GS).

① Technological Distance

Initially, technological distance is examined. Existing literature has predominantly measured technological distance between the leader and the rest of the ecosystem from a patent perspective (Bar & Leiponen, 2012; Kay et al., 2014; Aharonson & Schilling, 2016; Forman & Van, 2019). In view of this, the present paper first constructs the technological innovation capacity of the leaders. The natural logarithm of the number of patent applications plus one is selected as the proxy variable for the technological innovation capacity of the enterprise. Technological distance ($TD_{i,t}$) is defined as the difference between the number of patent applications of the technology leader enterprise i and the average number of patent applications of other enterprises in the same industry in year t .

② Government Subsidies

Since 2007, government subsidies have been identified as a significant component of Chinese enterprises' financial statements, and can be directly extracted from these statements. Government subsidies ($GS_{i,t}$) are measured as the ratio of government subsidies received by leader i in year t to its operating income. The existence of such subsidies has been proven to provide financial support for enterprises, demonstrate government support, and encourage leaders to continue innovating in the innovation ecosystem (Nicholson et al., 2005).

3.3 Models

This study constructs an empirical model (8) to examine the impact of innovation information disclosure by keystone firms on their innovation ecosystem dominance. The specific model is as follows:

$$Leadership_{i,t} = \beta_0 + \beta_1 Inno_Disc_{i,t} + \beta_2 Inno_Disc_{i,t}^2 + \beta_i control_{i,t} + Year + Ind + Pro + \varepsilon_{i,t}$$

In this model, the subscript i indicates the enterprise, and the subscript t indicates the year. The dependent variable $Leadership_{i,t}$ indicates the innovation ecosystems leadership of enterprise i in year t . The explanatory variable $Inno_Disc_{i,t}$ indicates the innovation information disclosure level of enterprise i in year t , and $Inno_Disc_{i,t}^2$ is the quadratic term of the disclosure level. It is important to note that, given the principle that innovation information disclosure does not immediately affect the innovation ecosystems leadership of technology leaders, the latter is treated as one period lagged. The control variables employed in this study are a standard selection of common control variables. These include enterprise size ($Size$), listing age ($Listage$), return on total assets (ROA), leverage (Lev), the relative value of the enterprise as evaluated by the stock market on the development prospects of the enterprise ($TobinQ$), shareholding concentration ($Share$), board size ($Boardsize$), industry concentration (HHI). Finally, this paper also controls for the fixed effects at the level of year ($Year$), industry (Ind), and province (Pro), and for the random error term ($\varepsilon_{i,t}$). The standard errors of all estimates are adjusted by clustering at the individual firm level.

4. Results

4.1 Summary statistics

The results of the descriptive statistical analysis of the variables are shown in Table 1. The mean value of the dependent variable, innovation ecosystems leadership, is 0.138, the minimum value is 0.0153, and the maximum value is 2.234, indicating that there are significant differences in the innovation ecosystems leadership of each leader. The mean value of the independent variable, innovation disclosure, is 1.105, the minimum value is 0.177, and the maximum value is 3.394, indicating that there are significant differences in the innovation information disclosure practices of various technology leaders, and most companies are not willing to disclose information about their innovations. The remaining control variables all demonstrate discrepancies in capabilities among companies, which is consistent with empirical judgment.

Table 1 Descriptive statistics of the main variables.

	N	Mean	Std	Min	Max
Leadership	3665	0.138	0.239	0.0153	2.234
InnoDisc	3665	1.105	0.396	0.177	3.394
Size	3665	22.31	1.177	19.94	26.45
Lev	3665	0.389	0.173	0.0530	0.892
ROA	3665	0.0595	0.0593	-0.373	0.247
Share	3665	2.106	0.182	1.609	2.708
TobinQ	3665	2.088	1.255	0.803	9.817
Listage	3665	1.819	0.915	0	3.401
HHI	3665	0.110	0.0854	0.0387	0.509
Boardsize	3665	31.84	13.44	4.794	84.73

4.2 Benchmark regression

Firstly, the relationship between innovation disclosure and innovation ecosystems leadership is examined. Table 2 presents the corresponding regression results. Model (1) explores the regression results without adding control variables, industry fixed effects, province fixed effects, and time fixed effects. The coefficient of the innovation disclosure primary term is negative and significant at the 0.1% level, while the

coefficient of the innovation disclosure secondary term is positive and significant at the 1% level. Model (2) incorporates additional control variables, while Model (3) adds industry fixed effects, province fixed effects, time fixed effects, and other variables to Model (2). The findings reveal that the primary and secondary disclosure of innovation information remains statistically significant, exhibiting an inverse relationship. This finding suggests the presence of a 'positive U-shaped' relationship between innovation disclosure and leadership.

To further explore this 'U-shaped' relationship, this paper employs the test proposed by Lind and Mehlum (2010), as outlined in model (3) in Table 2. This aims to confirm that the inflection point data falls within the specified interval. The outcomes of this test are presented in Table 3. The lower bound slope of the industry chain integration (0.1773) is significant at the 5% level, and the upper bound slope (3.394) is significant at the 5% level. Concurrently, the extremum point of the U-shaped curve is 1.378, which is within the range of the data. In addition, the Sasabuchi-Lind-Mehlum test rejects the null hypothesis. The outcomes corroborate Hypothesis 1, which stipulates the existence of a 'U-shaped' relationship between innovation disclosure and innovation ecosystems leadership (as illustrated in Figure 6). This hypothesis posits that initial innovation disclosure by the leader does indeed expose its core technology, R&D agenda and innovation goals to a certain extent, thereby reducing the cost of innovation breakthroughs for the remaining enterprises and weakening leadership. However, as the degree of innovation information disclosure increases, the strategic value brought about by information disclosure can fully communicate to the rest of the players in the innovation ecosystem the technological, innovative and management advantages they currently possess, cultivating followers and thereby enhancing innovation ecosystems leadership. It is at this juncture that the enhancement in leadership outstrips the initial value of non-disclosure.

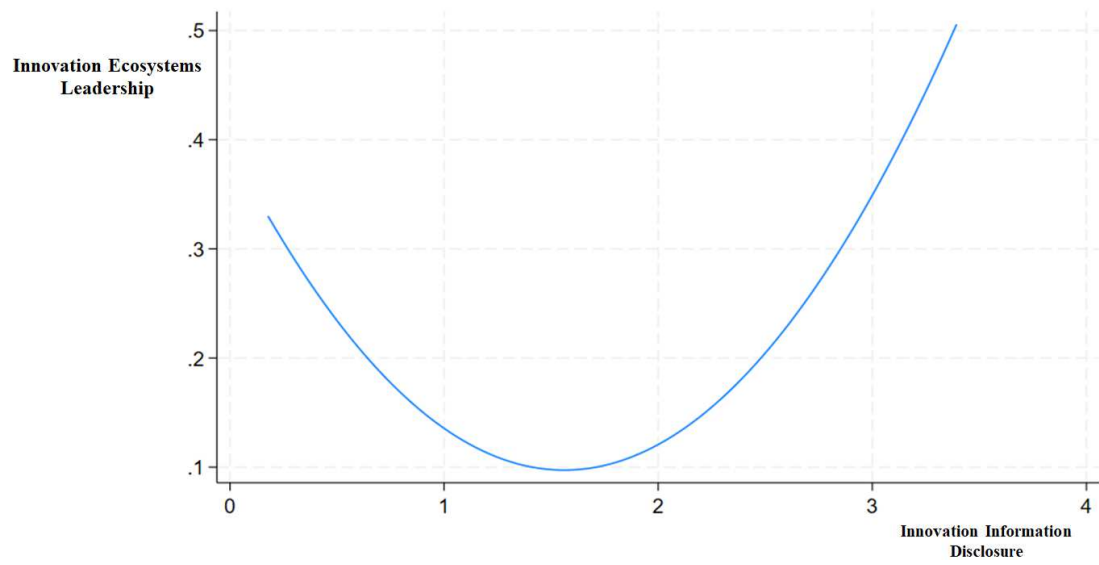


Figure 5 The Relationship Between Innovation Disclosure and Innovation Ecosystem Leadership

Table 2 Benchmark regression

	(1) Leadership	(2) Leadership	(3) Leadership
InnoDisc	-0.3797*** (-3.2019)	-0.2565*** (-2.8033)	-0.1946** (-2.1083)
InnoDisc ²	0.1216** (2.5664)	0.0907** (2.3759)	0.0706** (1.9807)
Size		0.1032*** (5.8562)	0.0954*** (6.5064)
Listage		-0.0207** (-2.1390)	-0.0147 (-1.3354)
ROA		0.3410*** (3.4399)	0.2233*** (2.8086)
Lev		-0.0289 (-0.4870)	-0.0062 (-0.1552)
TobinQ		-0.0106*** (-2.7953)	-0.0060 (-1.5580)
Boardsize		0.0183 (0.4484)	0.0140 (0.3554)
Share		-0.0005 (-0.7997)	-0.0003 (-0.6234)
HHI		0.3660*** (2.8323)	0.0151 (0.0610)
Constant	0.3936*** (5.0973)	-0.2565*** (-2.8033)	-0.1946** (-2.1083)
Province FE	No	No	Yes
Industry FE	No	No	Yes
Year FE	No	No	Yes
N	3665	3665	3665
Adjust R ²	0.026	0.259	0.375

Note: Values in parentheses represent t-values. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Unless otherwise specified, all subsequent tests report t-values adjusted using robust standard errors clustered at the individual level and have passed the U-test verification.

In economic terms, as illustrated in Table 2, Model (3), the coefficient of the innovation disclosure (InnoDisc) is -0.1946 for the first term and 0.0706 for the second term, indicating that to the left of the inflection point (0.0141), for every 1% increase in the innovation disclosure level of the leader, the leadership decreases by 0.194 units. Conversely, on the right side of the inflection point, for every 1% increase in the innovation disclosure level of the leader, the leadership increases by 0.071 units, which

is economically significant. Furthermore, when considered in conjunction with the mean innovation disclosure of 1.105 in Table 1, it becomes evident that the innovation disclosure level of the majority of leaders remains below the inflection point. This suggests that leaders have the capacity to further increase their innovation disclosure level, communicate their technological leadership and innovation advantages in emerging technology fields to innovation ecosystems, cultivate followers, and thereby gain leadership.

Table 3: Test Results of the "U-shaped" Relationship

Dependent variable: leadership	
Data range of innovation disclosure	[0.00177; 0.0300]
Lower bound slope	0.1773 ^{**}
Upper bound slope	3.3940 ^{**}
Sasabuchi-Lind-Mehlum Test for an inverted U-shape relationship	1.79 ^{**}
Extreme point	1.378096

4.3 Endogeneity tests

This paper considers the influence of variables such as the strength of the innovation capabilities of leaders on their innovation ecosystems leadership. In order to circumvent the endogeneity problems caused by omitted variables, this paper employs the propensity score matching method (PSM) for testing.

Initially, the sample is divided into two groups based on the level of innovation disclosure: a high innovation disclosure group (Treat=1) and a low innovation disclosure group (Treat=0). Those above the median are designated as the high innovation disclosure group, while those below the median are designated as the low innovation disclosure group. It is acknowledged that innovation disclosure is the voluntary choice of the leader, and thus there is a possibility of a self-selection problem. This problem leads to bias in sample selection, and consequently, it becomes impossible to compare the high innovation disclosure group with the low innovation disclosure group. The propensity score matching (PSM) method is therefore employed to address this issue.

The following variables were utilised as matching variables: firm size (Size), years listed (Listage), return on total assets (ROA), leverage (Lev), the relative value of the firm as evaluated by the stock market on the development prospects of the enterprise (TobinQ), shareholding concentration (Share), board size (Boardsize) and industry concentration (HHI). The nearest neighbour matching method was used to match a total of 3,706 sample data.

Subsequently, the balance of the matched assessment was conducted. As demonstrated in Figures 7 and 8, the PSM matching scores indicate an even distribution and a negligible standardized bias of less than 10%. The outcomes of all t-test analyses rejected the null hypothesis, thereby confirming the parallel hypothesis. This suggests that there is no systematic difference between the treatment and control groups.

Finally, the matched sample data was regressed. The regression results are reported in Table 4 Model (4). The regression results in Table 4 demonstrate the strong alignment of Model (3) in Table 3 with the earlier benchmark regression results, thereby substantiating the robustness of the research conclusions presented in this paper.

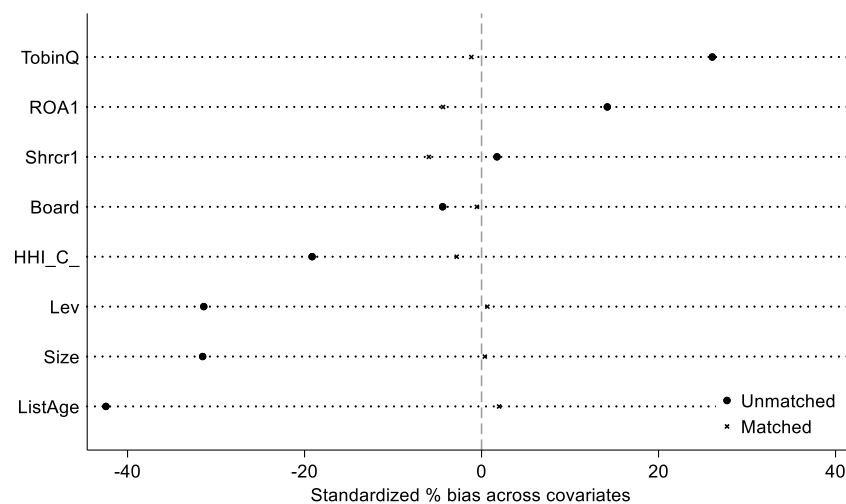


Figure 6: PSM Matching Score

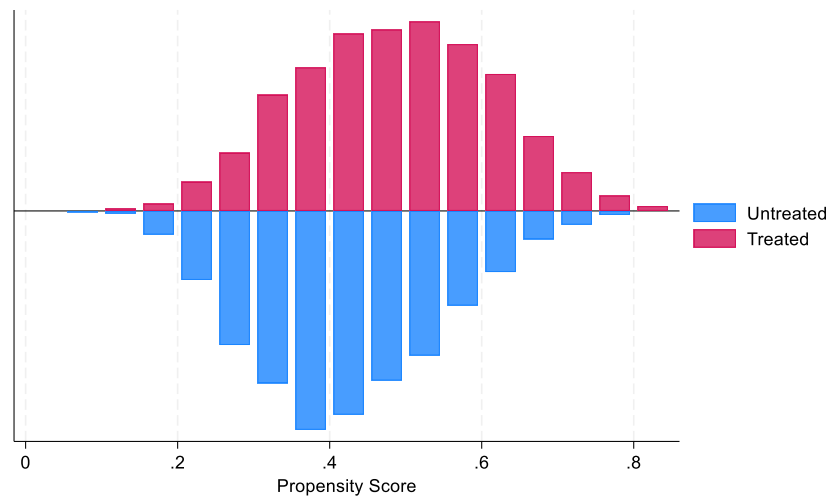


Figure 7: PSM Matching Score Plot

Table 4: Endogeneity tests

	(4) Leadership
InnoDisc	-0.1545** (-1.9974)
InnoDisc ²	0.0597* (1.7672)
Size	0.0767*** (5.1792)
Listage	-0.0104 (-1.0155)
ROA	0.2356*** (2.7874)
Lev	0.0416 (1.4454)
TobinQ	-0.0059 (-1.6341)
Boardsize	-0.0054 (-0.1333)
Share	-0.0005 (-1.0433)
HHI	0.3866 (1.4697)
Constant	-1.242*** (-3.4358)
Province FE	Yes
Industry FE	Yes
Year FE	Yes
N	3289
Adjust R ²	0.300

4.4 Robustness tests

In order to verify the robustness of the estimation results, a series of robustness tests are conducted. These consist of altering the core variable indicators, changing clustering methods, adjusting estimation methods, changing samples, ruling out interference from other events and testing for a potential cubic relationship.

4.4.1. Altering the core variable indicators

In this paper, the innovation ecosystems leadership of the leader enterprise is synthesised using principal component analysis dimensionality reduction from the three dimensions of industrial chain integration, technology leadership, and market position. In order to verify the robustness of the conclusions, the entropy weight method is employed to recalculate the weights of the three dimensions of leadership and to calculate the leadership scores of the leaders for each year. The regression results are reported in Table 5, Model (5). It is evident from the findings that the innovation disclosure terms maintain their significance at the 5% level.

4.4.2. Changing clustering methods

In consideration of the potential impact of industry characteristics and regional macroeconomic factors on the estimation results, the present study has followed existing research by clustering the standard errors at the regional and provincial levels in the model. The results are presented in Table 5, Models (6) and (7). Model (5) employs industry-level clustering adjustments, while Model (6) implements regional-level clustering adjustments. The findings indicate that the quadratic term of innovation disclosure remains significant and negative, reinforcing the presence of a quadratic relationship between innovation disclosure and leadership.

Table 5: Altering the core variable indicators and Changing clustering methods

	(5) Leadership	(6) Leadership	(7) Leadership
InnoDisc	-0.0051** (-2.0211)	-0.1946* (-2.0639)	-0.1946*** (-2.9649)
InnoDisc ²	0.0019** (2.0121)	0.0706* (1.9059)	0.0706** (2.5635)
Size	0.0038*** (7.0841)	0.0954*** (4.4694)	0.0954*** (11.3250)
Listage	-0.0001 (-0.3907)	-0.0147 (-0.9771)	-0.0147 (-0.8756)
ROA	0.0062** (2.3093)	0.2233** (2.5927)	0.2233** (2.3845)
Lev	-0.0006 (-0.4278)	-0.0062 (-0.1410)	-0.0062 (-0.1249)
TobinQ	-0.0002 (-1.2380)	-0.0060 (-1.6294)	-0.0060 (-1.5037)
Boardsize	0.0000 (0.0017)	0.0140 (0.3681)	0.0140 (0.5144)
Share	-0.0000 (-1.1329)	-0.0003 (-0.4459)	-0.0003 (-0.5775)
HHI	-0.0076 (-1.1191)	0.0151 (0.0731)	0.0151 (0.1097)
Constant	-0.0662*** (-6.3350)	-1.8641*** (-4.1564)	-1.8641*** (-7.8059)
Province FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	3665	3664	3664
Adjust R ²	0.436	0.380	0.380

4.4.3. Adjusting estimation methods

The dependent variable in this study, innovation disclosure, is concentrated within the [0,1] range and exhibits a mixed characteristic of zero-value piling (pile) coexisting with a continuous distribution of positive values. In order to address this data structure, a Tobit model was employed in the robustness checks. The regression results, as presented in Table 6, Model (8), indicate that the findings remain significant.

4.4.4. Changing samples and ruling out interference from other events

In the baseline regression of this study, a 99% winsorization level was applied in

order to mitigate the influence of extreme values on the results. To further ensure the robustness of the findings, a 5% winsorization level was adopted. The regression results, presented in Table 6, Model (9), demonstrate that the findings maintain significance, thus passing the robustness check. Given the study's time window from 2016 to 2022, which includes the potential external influence of the 2020 pandemic, the 2020 sample data was excluded to address any potential bias. The regression results, excluding the 2020 data, are presented in Table 6, Model (10), and demonstrate that the relationship between innovation disclosure and innovation ecosystem leadership remains significant.

Table 6: Adjusting estimation methods ,Changing samples and ruling out interference from

	other events		
	(8) Leadership	(9) Leadership	(10) Leadership
InnoDisc	-0.1946** (-2.1251)	-0.0907** (-2.2740)	-0.1835** (-1.9663)
InnoDisc ²	0.0706** (1.9966)	0.0309* (1.9306)	0.0663* (1.8523)
Size	0.0954*** (6.5585)	0.0370*** (9.1433)	0.0954*** (6.4459)
Listage	-0.0147 (-1.3461)	-0.0040 (-1.0947)	-0.0173 (-1.6211)
ROA	0.2233*** (2.8311)	0.2075*** (6.4376)	0.1889** (2.4625)
Lev	-0.0062 (-0.1564)	0.0558*** (3.4062)	-0.0017 (-0.0431)
TobinQ	-0.0060 (-1.5705)	-0.0032** (-2.0451)	-0.0044 (-1.0732)
Boardsize	0.0140 (0.3583)	-0.0046 (-0.3223)	0.0225 (0.5602)
Share	-0.0003 (-0.6284)	0.0002 (1.0508)	-0.0003 (-0.5726)
HHI	0.0151 (0.0615)	-0.0361 (-0.6296)	-0.0062 (-0.0246)
Constant	-1.395*** (-4.3532)	-0.4515*** (-4.8837)	-1.381*** (-4.2290)
Province FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	3665	3665	3120
Adjust R ²	/	0.503	0.378

4.4.5. Testing for a Potential Cubic Relationship:

In order to eliminate the possibility of a cubic "N-shaped" relationship between innovation disclosure and innovation ecosystem leadership, this study incorporates a cubic term for innovation disclosure (InnoDisc³) in the baseline regression. The findings suggest that the cubic term does not enhance the model's fit, thereby offering stronger evidence for the existence of a "U-shaped" relationship.

Table 7: Testing for a Potential Cubic Relationship

	(11) Leadership
InnoDisc	-0.3473* (-1.7212)
InnoDisc ²	0.1868 (1.4514)
InnoDisc ³	-0.0264 (-1.1047)
Size	0.0955*** (6.5121)
Listage	-0.0150 (-1.3675)
ROA	0.2213*** (2.7937)
Lev	-0.0056 (-0.1389)
TobinQ	-0.0060 (-1.5585)
Boardsize	0.0130 (0.3316)
Share	-0.0004 (-0.6443)
HHI	0.0097 (0.0393)
Constant	-1.3468*** (-4.2836)
Province FE	Yes
Industry FE	Yes
Year FE	Yes
N	3665
Adjust R ²	0.380

4.5 Moderating effect

As posited by Aiken (1991) and Cohen (2013), the U-shaped moderating effect is comprised of two constituent parts. Initially, it is imperative to assess whether the U-shaped relationship becomes flatter or steeper. When the square of the explanatory variable interacts with the moderating variable and the coefficient is opposite, the U-shaped relationship becomes flatter, and vice versa, the U-shaped relationship becomes steeper. Secondly, it is necessary to test whether the inflection point of the U-shaped curve shifts. The inflection point of the U-shaped curve will shift to the right if the coefficient $\beta_1\beta_4 - \beta_2\beta_3 > 0$, and will shift to the left if the coefficient $\beta_1\beta_4 - \beta_2\beta_3 < 0$.

4.5.1. Internal Driver: The Impact of Technological Distance

The present study firstly examines the moderating relationship between technological distance of leaders and the disclosure of innovation information and ecological leadership. The regression results are displayed in Table 8, Model (12). The coefficient of innovation disclosure² × technological distance is found to be significant ($\beta = -0.0001$, $p < 0.05$), and the coefficients of innovation disclosure² × technological distance and innovation disclosure² are reciprocals of each other. This indicates that the technological distance of technology leaders moderates the relationship between the disclosure of innovation information and innovation ecosystems leadership. This outcome serves to verify the validity of Hypothesis H2. Furthermore, the coefficient $\beta_1\beta_4 - \beta_2\beta_3 < 0$ indicates that the inflection point shifts to the left, showing that, under the moderating effect of technological distance, the turning point of the U-shaped relationship will be reached more quickly. It is evident that an increase in the technological distance of the leader will result in a more rapid arrival of leadership. To present the changing trends of innovation information disclosure and innovation ecosystems leadership in a more intuitive manner, a moderation effect graph is drawn (see Figure 9).

4.5.2. External Driver: The Effect of Government Subsidies

This paper further explores the moderating relationship between government subsidies and the relationship between innovation disclosure and leadership among leaders. The regression results are displayed in Table 8, Model (13). The coefficient of innovation disclosure two times government subsidies is significant ($\beta = -4.2333$, $p < 0.05$), and the coefficients of innovation disclosure two times government subsidies and innovation disclosure two are reciprocal of each other. This indicates that government subsidies play a moderating role in the relationship between innovation information disclosure and innovation ecosystems leadership among leaders. This outcome serves to verify the validity of Hypothesis H3. Furthermore, the coefficient $\beta_1\beta_4 - \beta_2\beta_3 < 0$ indicates that the moderating effect of Government Subsidies, the U-shaped relationship, reaches a critical point faster, that is, the greater the intensity of Government Subsidies, the more it can encourage technology leaders to disclose innovation information to enhance their leadership in innovation ecosystems. To present the changing trends of innovation disclosure and innovation ecosystems leadership in a more intuitive way, a further moderation effect graph is plotted (see Figure 10).

Tabel 8 : Moderating effect

	(12) Leadership	(13) Leadership
InnoDisc	-0.1864** (-2.0226)	-0.2016* (-1.8904)
InnoDisc ²	0.0673* (1.8936)	0.0800* (1.7681)
Technological Distance	0.00014 (0.9759)	
InnoDisc×Technological Distance	0.0005*** (2.6369)	
InnoDisc ² ×Technological Distance	-0.0001** (-2.4338)	
Government Subsidies		-1.8735*** (-3.6023)
InnoDisc×Government Subsidies		12.9423** (2.5822)
InnoDisc ² ×Government Subsidies		-4.2333** (-2.1594)
Size	0.0913*** (6.2838)	0.0943*** (6.4807)
Listage	-0.0135 (-1.2151)	-0.0175 (-1.6128)
ROA	0.2124*** (2.7694)	0.1694** (2.1597)
Lev	-0.0030 (-0.0765)	-0.0190 (-0.4707)
TobinQ	-0.0059 (-1.5340)	-0.0052 (-1.3954)
Boardsize	0.0202 (0.5359)	0.0184 (0.4664)
Share	-0.0003 (-0.5270)	-0.0005 (-0.8369)
HHI	0.0038 (0.0152)	0.0312 (0.1290)
Constant	-1.3283*** (-4.0542)	-1.3608*** (-4.2748)
Province FE	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	3665	3665
Adjust R ²	0.390	0.386

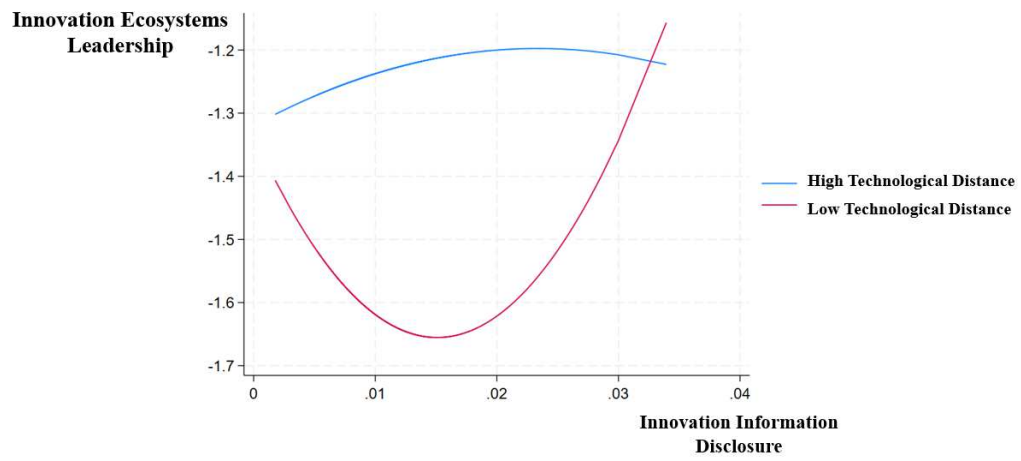


Figure 8 Internal Driver: The Impact of Technological Distance

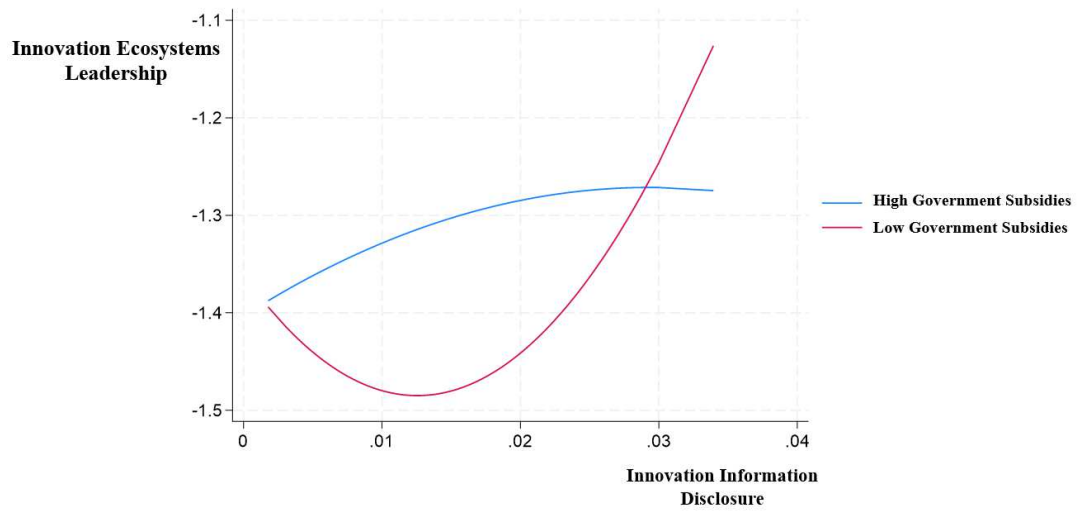


Figure 9 External Driver: The Effect of Government Subsidies

5. Additional analysis

5.1 Fact-check on the leader's reinforced innovation disclosure

The present study employs a baseline regression to explore the U-shaped relationship between innovation disclosure and innovation ecosystems leadership. For technology leaders, insufficient innovation disclosure may result in a weakening of their leadership, while adequate innovation disclosure can contribute to an enhancement of their leadership. Technology leaders, cognisant of this dynamic, may be predisposed to adopt an opportunistic strategy, whereby they ensure comprehensive innovation disclosure while moderately exaggerating their innovation results, enthusiastically depict the ecosystem's extensive development blueprint, and directly or indirectly enhance innovation information disclosure (Schrand & Walther, 2000; Li, 2010). The objective of this strategy is to create a deterrent effect among competitors, while attracting more followers to develop along their technological path, thereby strengthening the entire innovation ecosystem and gaining more promotion of innovation ecosystems leadership (see Figure 11).

In view of this, the present paper will further explore whether technology leaders engage in behaviours that strengthen innovation disclosure, describe innovation visions, and analyse the possible impact of such exaggeration and strengthening from the perspective of follower companies.

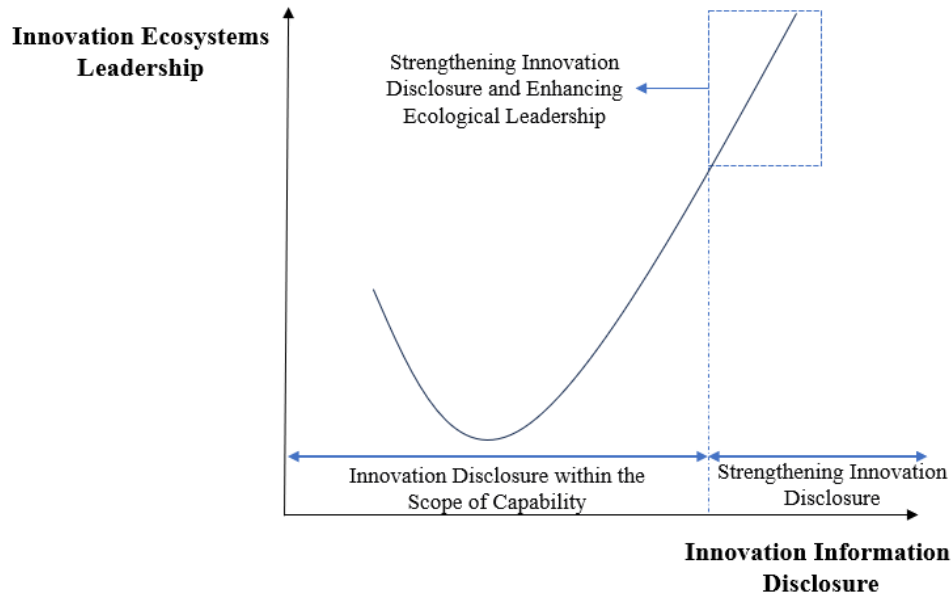


Figure 10 Strengthening the Manipulation of Innovation Information Disclosure to Enhance Ecological Leadership

The present paper proposes a model (Model 9) for the purpose of assessing the extent to which innovation is disclosed. This model is constructed by referring to the information exaggeration construction methods of Zhao et al. (2020), Chen et al. (2021) and Cao et al. (2023), in combination with the innovation inconsistency proposed by Qiu and Li (2024).

$$\begin{aligned}
 Inno_Disc_{i,t} = & \beta_0 + \beta_1 Inno_Disc_IND_{i,t} + \beta_2 COMP_IND_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \\
 & \beta_5 CASHFLOW + \beta_6 PPE_{i,t} + \beta_7 TOP1_{i,t} + \beta_8 AGE_{i,t} + \beta_9 RDF_{i,t} + \\
 & \beta_{10} TEC_{i,t} + \beta_{11} GPY_{i,t} + FIRM + YEAR + \varepsilon_{i,t}
 \end{aligned}
 \tag{9}$$

The dependent variable is defined consistently with earlier sections, while the independent variables include the industry-average innovation disclosure level (COMP_IND), industry competition intensity (COMP_IND), firm size (SIZE), leverage ratio (LEV), cash flow ratio (CASHFLOW), proportion of fixed assets (PPE), shareholding ratio of the largest shareholder (TOP1), firm age (AGE), R&D investment (RDF), annual patent applications (TEC), annual patent grants (GPY), as well as firm

fixed effects and year fixed effects. The model regresses innovation disclosure levels to estimate the normal level of disclosure for leaders. The residual (ε) represents the level of reinforced innovation disclosure (AB_InnoDisc). When $\varepsilon > 0$, it indicates that the leaders' innovation disclosure exceeds the normal disclosure level, signifying reinforced innovation disclosure behavior. Conversely, when $\varepsilon \leq 0$, it indicates that the firm's innovation disclosure is below or equal to the normal level, implying no reinforced disclosure behavior.

The concluding regression results are presented in Table 9. Model (15) explores the fundamental relationship between reinforced innovation disclosure and innovation ecosystems leadership. The findings demonstrate that the coefficient of reinforced innovation disclosure is significant ($\beta = 131.7921$, $p < 0.01$). This suggests that technology leaders proactively seek to reinforce their innovation ecosystems leadership by reinforced innovation disclosure.

Tabel 9 Additional analysis

	(15) Leadership	(16) FC	(17) EIR
AB_ InnoDisc	131.7921*** (2.7355)		
AB_ InnoDisc_AVA		41.5358** (2.4196)	-9.4218** (-2.2308)
Size	0.0560*** (4.4467)	-0.1971*** (-52.8950)	-0.0089*** (-7.9427)
Listage	0.0112 (0.8755)	-0.0198*** (-6.9855)	0.0019** (2.3060)
ROA	0.2395*** (3.3445)	0.5403*** (21.7678)	0.0212*** (3.4415)
Lev	0.0606 (1.5726)	-0.2124*** (-15.0616)	0.0082*** (2.7886)
TobinQ	-0.0090** (-2.4196)	-0.0400*** (-22.1262)	-0.0012*** (-3.3857)
Boardsize	0.0336 (0.8898)	-0.0199** (-2.1890)	-0.0045* (-1.7640)
Share	-0.0028** (-2.4751)	-0.0001 (-0.7564)	-0.0001 (-1.2137)
HHI	-0.0803 (-0.3182)	-0.0248 (-0.3031)	0.0468*** (2.6269)
Constant	-1.8869*** (-4.3751)	4.6008*** (23.9697)	0.2912*** (5.5772)
Province FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	3650	9058	9021
Adjust R ²	0.3817	0.832	0.115

5.2 Leader in technology: Reinforced innovation disclosure has consequences for followers

The findings indicate that technology leaders, in their endeavours to consolidate their prevailing position, tend to overstate the significance of information disclosure as a means to augment its effect. However, it is imperative to consider the potential ramifications of this behaviour on followers. In this regard, the present study shifts the research perspective to followers, with a view to assessing the potential impact of technology leaders' strengthened innovation disclosure on the entire ecosystem. Firstly, the time window under consideration is 2016-2022, and followers are defined as unlisted companies in the same industry as the technology leaders. The industry classification is based on the secondary classification standard of the 'Guidelines for Industry Classification of Listed Companies'. The specific data processing method remains unchanged. The following empirical model is constructed with reference to Lu et al (2024) and Sun & Dong (2024):

$$EC_{i,j,t} = \beta_0 + \beta_1 AB_Inno_Disc_AVA_{j,t} + \beta_i control_{i,t,j} + Year + Ind + Pro + \epsilon_{i,t}$$

In this study, the 'i', 'j' and 't' are used to represent followers, industry and year, respectively. The dependent variable $EC_{i,j,t}$ denotes the economic consequences received by follower i in industry j in year t. The core explanatory variable $AB_Inno_Disc_AVA_{j,t}$ signifies the average innovation information disclosure exaggeration of the leader in industry j in year t. To circumvent lag, the data is processed one period behind. The remaining fixed effects, clustering levels, and control variables are consistent with those previously outlined.

The regression results are displayed in Table 9. Initially, the coefficient of the effect of reinforced innovation disclosure on the financing constraints of followers is significant in Model (16) ($\beta=41.5358$, $p<0.05$). Secondly, following Lu and Xu (2024), the innovation resilience level of followers is assessed by the change in the number of patent applications of the follower enterprise, where EIR is the relative innovation resilience of sample enterprise i in year t. The larger the value, the better the enterprise's

innovation resilience performance, and vice versa. Finally, the coefficient of influence of reinforced innovation disclosure on followers' innovation resilience in model (17) is significant ($\beta = -9.4218$, $p < 0.05$).

$$\begin{aligned} EIR_{i,t} &= (\Delta P_i - \Delta E) / |\Delta E| \\ \Delta P_i &= P_{i,t} - P_{i,t-1} \\ \Delta E &= ((P_{c,t} - P_{c,t-1})P_{c,t-1})P_{i,t-1} \end{aligned} \quad (10)$$

This demonstrates that the behaviour of technology leaders in disclosing innovation in a reinforced manner may result in misleading followers, thereby hindering their ability to ascertain a clear technological development path. This, in turn, can lead to a loss of focus in innovation strategies and resource allocation. This deceptive conduct not only undermines the innovation resilience of followers, impeding their capacity to adapt to changes and revert to the customary technological development trajectory, but also perpetuates the distortion of expectations regarding technological development within the ecosystem. Objectively, this behaviour hinders followers' ability to obtain resources, undermines the ecosystem's fundamental trust, and consequently exerts a detrimental influence on the long-term health and stable development of the ecosystem.

5.3 The consequences of a decrease in followers: Reinforced innovation disclosure by technology leaders

In view of the aforementioned, this paper further explores how followers and technology leaders should take action to dispel the exaggerated innovation information disclosure of technology leaders and reduce the negative impact of exaggerated innovation information disclosure. The proportion of R&D personnel is utilised as a metric to assess the innovation atmosphere (AT) within an enterprise. The regression results are presented in Table 10. The regression results in Models (18) and (19), the innovation atmosphere coefficient of followers are significant, with $\beta = -1.4955$, $p < 0.01$ and $\beta = -0.2689$, $p < 0.1$, respectively. These findings suggest that a favourable

innovation atmosphere among followers is indicative of a concentration of professionals, excellent resource acquisition and integration capabilities, and heightened sensitivity to technological innovation. The advantages identified enable the effective identification and elimination of exaggerated reinforcement components in the innovation information disclosure of leaders, the effective demystification of innovation information, and the consequent reduction of confusion regarding resource allocation and the weakening of innovation resilience. Moreover, it is incumbent upon technology leaders to be attentive to followers and the prevailing sentiment within the innovation ecosystem, and to adjust the intensity of enhanced disclosure in a timely manner. This reciprocal relationship is pivotal in facilitating the acquisition of valuable knowledge by followers from the innovation information disclosed by leaders, thereby laying a solid foundation for their own high-quality innovation outcomes. Moreover, technology leaders can also enhance their leadership skills through enhanced disclosure and contribute to the continuous development of a healthy innovation ecosystem.

Tabel 10 Testing for the disillusionment effect

	(16)	(17)
	FC	EIR
AB_ InnoDisc_ AVA	55.9103*** (3.0395)	-11.5838*** (-2.6570)
IT	0.0002 (1.0443)	-0.000035 (-0.8500)
AB_ InnoDisc_ AVA×IT	-1.4955*** (-2.6830)	0.2689* (1.8525)
Size	-0.1980*** (-52.8367)	-0.0089*** (-7.9240)
Listage	-0.0188*** (-6.5498)	0.0020** (2.3389)
ROA	0.5398*** (21.6819)	0.0217*** (3.5410)
Lev	-0.2043*** (-14.7868)	0.0081*** (2.7060)
TobinQ	-0.0398*** (-21.8370)	-0.0011*** (-3.1494)
Boardsize	-0.0199** (-2.1929)	-0.0041 (-1.6216)
Share	-0.0001 (-0.7329)	-0.0000 (-1.1533)
HHI	-0.0460 (-0.5397)	0.0571*** (3.2139)
Constant	4.4692*** (21.6771)	0.3143*** (5.8704)
Province FE	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	8952	8916
Adjust R ²	0.834	0.116

6. Conclusions

6.1. Research Conclusions

This paper analyses the paradoxical challenges posed by the disclosure of innovation information by technology leaders and its impact on innovation ecosystem leadership based on the leader paradox perspective, using data on China's A-share listed technology leaders from 2016 to 2022. The research findings are as follows:

(1) In the innovation ecosystem, the disclosure of innovation information by technology leaders triggers the contradictory tension of 'challenger' and 'follower'. As the technology leader increases its disclosure of innovation information, these two forces interact to produce a U-shaped effect on its innovation ecosystem leadership. When the technology leader fails to adequately disclose its innovations, this not only provides competitors with opportunities to imitate and narrow the technology gap, but also leads followers to doubt the innovation strength of the technology leader and reduce their willingness to cooperate and learn with them. Conversely, when the technology leader discloses its innovation information in full, this strategy deters competitors while enhancing followers' recognition of the technology leader's innovation achievements, promoting mutual recognition of the value enhancement brought about by cooperation, establishing a closer learning and cooperative relationship, rapidly strengthening followers, and thus consolidating and enhancing its leading position in the innovation ecosystem.

(2) Various driving factors, including technological distance within the technology leader and external policy support, play a weakening and moderating role in the U-shaped relationship between innovation information disclosure and innovation ecosystem leadership. These factors can lead to an early inflection point, helping the technology leader to more quickly enhance its ecosystem leadership through information disclosure.

(3) In practice, technology leaders strengthen innovation disclosure to seek greater improvement in ecosystem leadership. Specifically, when a technology leader ensures the integrity of its innovation information disclosure, it can exaggerate its innovation

achievements moderately to strengthen innovation information disclosure, thereby gaining more leadership. From the perspective of a technology leader, strengthening innovation information disclosure does indeed achieve the goal of consolidating and enhancing ecological leadership. However, followers should be cognizant of the fact that this strengthening behaviour may result in difficulties in resource allocation, weaken their innovation resilience, and divert them from the innovation path, which in turn has a negative impact on the healthy development of the entire ecosystem. Consequently, followers must cultivate a robust internal innovation culture, which can help them disillusion the exaggerations of technology leaders and mitigate these adverse effects. Conversely, leaders must pay close attention to the innovation atmosphere of their followers at all times. In order to consolidate their position of dominance, it is imperative that they also ensure the long-term sustainability of the innovation ecosystem.

6.2. Managerial and Policy Implications

(1) Implications for Leaders:

① It is evident that technology leaders face a choice paradox in the innovation ecosystem, namely that they must either adopt an open strategy of full disclosure of innovation information or a closed strategy of selective disclosure. While a conservative strategy can indeed prevent the leakage of key innovation information, thereby ensuring that competitors cannot easily challenge their dominant position, and can in the short term help them consolidate and maintain their dominant position in the ecosystem, it is not conducive to the long-term healthy development of the innovation ecosystem and inhibits the ability of followers to absorb and utilise advanced knowledge. Conversely, an open strategy, characterised by the comprehensive dissemination of innovation information, has the potential to stimulate technological progress and growth among followers, guiding them along a specific technological trajectory. Moreover, it exerts a deterrent effect on competitors, encouraging them to

collaborate with technology leaders to collectively foster the prosperity and sustainable development of the innovation ecosystem. This ultimately enables technology leaders to enhance their innovation ecosystem leadership more effectively than with a conservative strategy.

② Technology leaders should continue to increase their investment in research and development and strengthen their technological self-reliance. By maintaining a leading edge in technological distance, an open disclosure strategy can more quickly bring about an increase in innovation ecosystem leadership, more effectively diffuse advanced technologies to followers, help them grow rapidly, and achieve the prosperity of the innovation ecosystem.

③ Technology leaders should be as cautious as possible in the process of innovation disclosure, exaggerating their innovation results to enhance the effect of innovation disclosure. While this approach may temporarily enhance the ecological leadership of the technology leader, it can lead to imbalances in resource allocation among followers and a decline in innovation resilience over time, potentially hindering the ecosystem's long-term healthy development. Consequently, technology leaders must consistently monitor the innovation environment of their followers and the ecosystem, and proactively enhance the ecosystem's overall innovation atmosphere through the organisation of ecological and technological exchange meetings, among other measures. This approach is crucial for ensuring the long-term sustainability and resilience of the innovation ecosystem.

(2) Implications for Government:

For the government, it should proactively fulfil the role of a 'capable government' to cultivate technology leaders and establish a favourable environment for them to disclose their innovations by formulating incentive policies and strengthening the protection of intellectual property rights. This will alleviate the difficulties and paradoxes faced by technology leaders in disclosing their innovations, help them consolidate and enhance their innovation ecosystem leadership and play a leading role more quickly through the disclosure of innovations.

(3) Implications for Followers in the Ecosystem:

followers of technology leaders within the innovation ecosystem must strengthen the innovation atmosphere. On the one hand, a positive innovation atmosphere can help followers dispel the myth of technology leaders' enhanced innovation disclosure and reduce the negative impact of such disclosure. Conversely, a robust innovation atmosphere can facilitate the assimilation, absorption, and utilisation of technology leaders' innovation disclosure by followers, fostering the acquisition of advanced technological knowledge and, consequently, the enhancement of their own innovation capabilities.

6.3. Limitations and future research directions

This study also has the following limitations:

① **Measurement of innovation ecosystem leadership requires further improvement.** The use of principal component analysis (PCA) and entropy weight methods to quantify the leadership of keystone firms may lead to some distortion of data information.

② **Innovation disclosure measurement is not fully mature.** While the study uses textual analysis to comprehensively capture the innovation disclosure information of keystone firms, the method cannot adequately reflect differences in disclosure levels among firms of varying sizes. The scientific rigor of the measurement approach still requires further refinement.

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