



Patient Capital and Disruptive Technological Innovation: A Dynamic Model of Firms' Technology Choice

Yuanlin Wu^{1a}, Huajun Zheng^{2b*}

¹School of Economics and Trade, Guangdong Mechanical and Electrical Polytechnic,
Guangzhou, China

²School of Economics and Management, Guangzhou Vocational University of Science and
Technology, Guangzhou, China

^ascholars510@163.com, ^{b*}jnuscholars@163.com

Abstract. Disruptive technological innovation is characterized by long development horizons, high uncertainty, and delayed returns, making firms' innovation strategies particularly sensitive to the time orientation of capital. Using panel data on Chinese A-share listed firms from 2011 to 2023, this study examines the relationship between patient capital and firms' disruptive technological innovation, measured by firms' entry into new technological domains based on patent-level International Patent Classification (IPC) codes. Employing a two-way fixed effects model, the results show that patient capital is positively associated with firms' disruptive technological innovation, including both disruptive invention and utility model patents, with stronger associations observed among non-state-owned firms, firms with lower financing constraints, larger firms, and those operating in high-technology industries. To interpret these empirical patterns, the study develops a dynamic theoretical framework linking capital time orientation to firms' technology choice under intertemporal trade-offs, highlighting how greater capital patience increases the relative attractiveness of innovation strategies with delayed and uncertain returns. By integrating formal theoretical analysis with firm-level evidence, this study provides a coherent perspective on how patient capital shapes the direction of technological innovation without relying on explicit mechanism testing.

Keywords: Patient capital; Disruptive technological innovation; Capital time orientation; Technological choice; Firm-level innovation

1 Introduction

Against the backdrop of the deepening new wave of technological revolution and industrial transformation, the directional nature of technological innovation has attracted increasing attention in academic research. Compared with incremental improvements along existing technological trajectories, disruptive technological innovation often introduces new combinations of technologies or knowledge structures that fundamentally reshape established technological systems and market landscapes, thereby serving as a

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critical driver of industrial upgrading and firms' long-term competitive advantage (Cuthbertson and Furseth, 2022^[1]; Allal-Chérif et al., 2023^[2]). However, disruptive innovation is typically characterized by long development cycles, high uncertainty, and substantial failure risk. Its realization depends not only on firms' internal technological capabilities but also crucially on how external capital is allocated over time (Curry et al., 2021^[3]; Neligan et al., 2023^[4]).

A large body of literature has pointed out that short-termism in capital markets may constrain firms' long-term innovation behavior. When firms are subject to frequent performance evaluations and stock price pressures, managers are more likely to allocate resources toward innovation activities with shorter payback periods and lower risk, thereby weakening incentives to engage in high-risk and long-horizon technological exploration (Keum, 2021^[5]; Xu et al., 2024^[6]). In this context, differences in investment horizons, risk preferences, and governance orientations across capital types may constitute an important institutional factor shaping firms' innovation direction.

In recent years, patient capital has emerged as a distinct form of capital emphasizing long-term investment orientation and has gradually entered academic discussion. Existing studies typically characterize patient capital through indicators such as stable long-term shareholding, low turnover rates, or relationship-based financing, and examine its implications for firms' investment decisions, R&D expenditures, and innovation outcomes (Raess, 2024^[7]; Gang and Hongrui, 2025^[8]). Overall, prior research suggests that patient capital tends to be more aligned with firms' long-term development objectives. However, its relationship with the structure of technological innovation—particularly with disruptive technological innovation as a higher-order form of innovation—has yet to be systematically examined.

Meanwhile, improvements in patent data availability have enabled researchers to develop methods for identifying disruptive technological innovation based on patent classification systems. Related studies commonly exploit changes in technological knowledge structures reflected in International Patent Classification (IPC) codes to identify whether firms enter new technological domains or depart from established technological paths. This approach provides a relatively objective and operational measure of disruptive innovation and has been widely adopted in the existing literature (Jia et al., 2021^[9]; Yang, 2025^[10]). Accordingly, this study does not treat the construction of disruptive innovation indicators or the measurement of patient capital as its primary contribution, but rather employs these established measures in a standardized manner.

Against this background, the central question addressed in this study is whether patient capital is systematically associated with firms' disruptive technological innovation under given institutional and capital market conditions, and whether this association varies across different types of firms. To answer this question, the study uses a sample of Chinese A-share listed firms from 2011 to 2023, constructs measures of patient capital and disruptive technological innovation based on existing literature, and examines their relationship within a unified empirical framework.

Relative to prior studies, the contribution of this paper lies primarily in the deepening and extension of theoretical analysis. Rather than remaining at the level of documenting empirical associations, the study develops a formal analytical model in the subsequent

theoretical section to systematically characterize the internal logic linking patient capital and disruptive technological innovation from the perspective of capital time preferences and firms' technological choices. By incorporating patient capital into a theoretical framework of firms' technology selection, this study aims to provide a more general analytical perspective on how capital attributes shape the direction of technological innovation and to offer a consistent theoretical foundation for the empirical findings.

2 Theoretical Analysis

2.1 Basic Setup

Consider a discrete-time, infinite-horizon firm decision problem indexed by $t = 0, 1, 2, \dots$. In each period, the firm chooses its technological strategy to maximize the expected discounted stream of profits. The firm's objective function is given by:

$$\max_{\{a_t\}} \mathbb{E} \sum_{t=0}^{\infty} \beta^t \pi_t(a_t) \quad (1)$$

where $\beta \in (0, 1)$ denotes the discount factor reflecting the degree to which future returns are valued by capital providers, a_t represents the firm's technological choice in period t , and $\pi_t(\cdot)$ denotes the corresponding profit function. A higher value of β indicates a stronger long-term orientation of capital, corresponding to a higher level of patient capital.

In each period, the firm can choose between two technological paths: incremental innovation along an existing technological trajectory, denoted by $a_t = I$, or entry into a new technological space through disruptive innovation, denoted by $a_t = D$. These two options differ systematically in their cost structures, timing of returns, and uncertainty profiles.

2.2 Technological Paths and Payoff Structure

Incremental innovation is characterized by relatively low initial costs and immediate, stable returns. The firm's per-period profit under incremental innovation is assumed to be:

$$\pi_t(I) = \bar{\pi} \quad (2)$$

where $\bar{\pi} > 0$ represents a constant and predictable profit level.

In contrast, disruptive technological innovation involves substantial upfront investment and delayed payoffs. Specifically, when a firm chooses disruptive innovation, it incurs a fixed R&D cost $C > 0$ in each of the first T periods, during which no positive profits are generated. Starting from period $T + 1$, conditional on successful innovation, the firm enters a new technological trajectory and obtains a higher and persistent profit flow π^D , where $\pi^D > \bar{\pi}$. For analytical tractability, the post-success profit stream is assumed to be constant over time.

Accordingly, the expected discounted payoff from disruptive innovation can be expressed as:

$$V_D = -\sum_{t=0}^T \beta^t C + \sum_{t=T+1}^{\infty} \beta^t \pi^D \quad (3)$$

By contrast, if the firm continuously adopts incremental innovation, the corresponding discounted payoff is given by:

$$V_I = \sum_{t=0}^{\infty} \beta^t \bar{\pi} \quad (4)$$

2.3 Technology Choice Condition

The firm compares the discounted values of the two technological paths and chooses disruptive innovation if and only if its expected payoff is no lower than that of incremental innovation:

$$V_D \geq V_I \quad (5)$$

Substituting equations (3) and (4) into inequality (5) yields:

$$-C \frac{1-\beta^{T+1}}{1-\beta} + \beta^{T+1} \frac{\pi^D}{1-\beta} \geq \frac{\bar{\pi}}{1-\beta} \quad (6)$$

Rearranging terms, the condition under which the firm undertakes disruptive technological innovation can be written as:

$$\beta^{T+1}(\pi^D - \bar{\pi}) \geq C(1 - \beta) \quad (7)$$

Equation (7) highlights that the firm's decision to pursue disruptive innovation depends jointly on the discount factor β , the innovation development horizon T , the long-run profit advantage $\pi^D - \bar{\pi}$, and the upfront R&D cost C .

2.4 Patient Capital and Disruptive Innovation

The discount factor β plays a central role in shaping the firm's technological choice. Differentiating the left-hand side of equation (7) with respect to β yields:

$$\frac{\partial}{\partial \beta} [\beta^{T+1}(\pi^D - \bar{\pi})] - C(1 - \beta) > 0 \quad (8)$$

This result indicates that, holding other parameters constant, a higher discount factor increases the likelihood that the condition for disruptive innovation is satisfied. Intuitively, when firms are backed by more patient capital, future high returns receive greater weight in current decision-making, thereby offsetting the high upfront costs and delayed payoffs associated with disruptive technological innovation.

Within this dynamic framework, patient capital expands the set of conditions under which disruptive innovation becomes an optimal technological choice, relative to incremental innovation.

Based on the analysis above, the model yields the following theoretical hypothesis:

Hypothesis: *Ceteris paribus*, a higher degree of capital patience increases the likelihood that a firm engages in disruptive technological innovation.

3 Study Design

3.1 Samples and Data

This study examines a panel of Chinese A-share firms listed on the Shanghai and Shenzhen Stock Exchanges over the period 2011–2023. Firm-level financial, governance, and ownership data are obtained from the China Stock Market and Accounting Research (CSMAR) database, which has been widely used in studies on corporate finance and innovation.

To ensure data reliability and sample comparability, several screening procedures are applied. First, firms in the financial sector are excluded due to their distinct regulatory frameworks and accounting practices. Second, companies designated as ST, *ST, or PT are removed to avoid distortions associated with abnormal operating conditions. Third, firm-year observations with missing key variables or clearly erroneous values are deleted. Finally, all continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of extreme outliers. After these procedures, the final sample consists of 13,197 firm-year observations.

3.2 Definition of Variables

3.2.1 Dependent Variable: Disruptive Technological Innovation (DTI).

The dependent variable is firms' disruptive technological innovation (DTI). Following established approaches in the literature (Kasinathan et al., 2022^[11]; Wang et al., 2022^[12]), this study identifies disruptive innovation based on the technological novelty embedded in patent classifications. Specifically, patents are classified using the International Patent Classification (IPC) system, where the first four digits of the IPC code capture the core technological domain and knowledge attributes of an invention.

A patent applied for by firm i in year t is identified as a disruptive technological patent if its corresponding IPC four-digit code has not appeared in the firm's patent portfolio during the preceding five years. This approach captures firms' entry into new technological spaces and has been widely adopted in prior research on technological discontinuities and disruptive innovation. Based on this identification strategy, DTI is measured as the number of disruptive technological patents granted to a firm in year t .

To further differentiate the technological nature of disruptive innovation, this study distinguishes between invention patents and utility model patents. Accordingly, disruptive invention patents and disruptive utility model patents are denoted as DTI_INV and DTI_UM, respectively.

3.2.2 Independent Variable: Patient Capital (PC).

The key independent variable is patient capital (PC). Consistent with the existing literature (Cremers and Pareek, 2016^[13]; Fichtner and Heemsker, 2022^[14]), patient

capital is captured from two complementary dimensions: strategic equity holdings and relationship-based debt financing. Given data availability and empirical tractability, the primary measure focuses on the equity dimension.

Specifically, patient capital is proxied by the shareholding ratio of strategic institutional investors. For each institutional investor, we compute the ratio of its current ownership stake to the standard deviation of its ownership over the previous three years, which reflects the stability of its shareholding behavior. This ratio is then compared with the industry-year median. If the ratio for a given investor is above the industry-year median, the investor is classified as a strategic (long-term) institutional investor; otherwise, it is classified as a transient (short-term) investor.

Firm-level patient capital (PC) is measured as the aggregate shareholding ratio of strategic institutional investors. This measure reflects the extent to which a firm's equity capital is characterized by long-term orientation and holding stability, consistent with the conceptual definition of patient capital in prior studies.

3.2.3 Control Variables.

To alleviate potential omitted-variable bias and enhance model explanatory power, a comprehensive set of control variables is included, covering firm characteristics, operating performance, corporate governance, and external monitoring.

Firm characteristics include firm size (Size), measured as the natural logarithm of total assets; firm age (Age), defined as the number of years since establishment; leverage (Lev), measured by the ratio of total liabilities to total assets; asset tangibility (Tang), measured as the ratio of tangible assets to total assets; and capital intensity (CapInt), measured as capital stock relative to labor input.

Operating performance variables include return on assets (Roa), Tobin's Q (TobinQ), and revenue growth rate (Growth), capturing profitability, market valuation, and growth potential, respectively.

Corporate governance and external monitoring variables include the shareholding ratio of the largest shareholder (Top1), board size (Board), managerial ownership (ManHold), and CEO duality (DUAL). In addition, audit quality (AUDIT), measured by whether the firm is audited by a Big Four accounting firm, and institutional ownership (InsHold) are included to capture external governance and monitoring intensity.

3.3 Model Setting

To examine the impact of patient capital on firms' disruptive technological innovation, this study employs a two-way fixed effects regression model specified as follows:

$$DTI_{i,t} = \alpha + \beta PC_{i,t} + \gamma X_{i,t} + \delta_i + \theta_t + \varepsilon_{i,t} \quad (9)$$

where $DTI_{i,t}$ denotes the disruptive technological innovation outcome of firm i in year t ; $PC_{i,t}$ represents patient capital; $X_{i,t}$ is a vector of control variables; δ_i denotes firm fixed effects capturing time-invariant unobserved heterogeneity; θ_t denotes year fixed effects controlling for macroeconomic shocks and common time trends; and $\varepsilon_{i,t}$ is the error term.

The coefficient of interest, β , captures the marginal effect of patient capital on firms' disruptive technological innovation. By incorporating both firm and year fixed effects, the model effectively controls for unobserved heterogeneity across firms and over time, thereby improving the reliability of the estimated relationship.

4 Empirical Results

4.1 Benchmark Regression

Table 1 reports the benchmark regression results examining the relationship between patient capital and firms' disruptive technological innovation. Columns (1)–(3) present the results using overall disruptive technological innovation (DTI), disruptive invention patents (DTI_INV), and disruptive utility model patents (DTI_UM) as dependent variables, respectively. All regressions include firm fixed effects and year fixed effects, and standard errors are clustered at the firm level.

Across all model specifications, the coefficient on patient capital (PC) is positive and statistically significant. In column (1), patient capital is significantly associated with a higher level of overall disruptive technological innovation, indicating that firms with a greater presence of long-term oriented capital tend to engage more intensively in disruptive innovation activities. This finding is consistent with the theoretical implication that a stronger long-term orientation in capital valuation is associated with a greater willingness to undertake innovation projects characterized by delayed and uncertain returns.

Columns (2) and (3) further distinguish between different types of disruptive innovation. The coefficient on patient capital remains positive and statistically significant for both disruptive invention patents and disruptive utility model patents. While the magnitude differs across patent types, the results suggest that patient capital is associated not only with high-threshold technological breakthroughs embodied in invention patents, but also with disruptive innovations at the application and implementation level. This pattern indicates that the relationship between patient capital and disruptive innovation is not confined to a single technological dimension.

Table 1. Benchmark regression results

Variables	(1)	(2)	(3)
	DTI	DTI INV	DTI UM
PC	0.005*** (2.66)	0.002** (2.00)	0.003** (2.54)
Size	2.236*** (7.81)	1.068*** (7.33)	1.185*** (6.51)
Roa	3.010 (1.21)	0.793 (0.63)	2.349 (1.49)
Age	-0.255 (-0.11)	0.983 (0.87)	-1.082 (-0.76)
Lev	-2.166*	-0.944*	-1.188*

	(-1.95)	(-1.67)	(-1.68)
Tang	-5.164**	-1.911*	-3.097**
	(-2.54)	(-1.85)	(-2.40)
TobinQ	-0.192	-0.161**	-0.027
	(-1.39)	(-2.28)	(-0.30)
Growth	2.391***	0.926***	1.439***
	(7.72)	(5.87)	(7.31)
CapInt	0.304***	0.122**	0.177***
	(3.02)	(2.38)	(2.77)
Top1	0.005	0.006	-0.004
	(0.29)	(0.74)	(-0.35)
Board	0.643	0.224	0.417
	(1.26)	(0.87)	(1.29)
ManHold	7.013***	2.951***	4.195***
	(3.48)	(2.88)	(3.28)
DUAL	0.293	0.059	0.242
	(0.96)	(0.38)	(1.24)
AUDIT	-0.884	-0.182	-0.677
	(-1.22)	(-0.50)	(-1.47)
InsHold	0.058***	0.030***	0.028***
	(4.86)	(4.95)	(3.68)
Constant	-42.020***	-24.278***	-18.694***
	(-4.46)	(-5.07)	(-3.12)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	13,197	13,197	13,197
R-squared	0.42	0.37	0.38

Notes: ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses beneath each coefficient.

4.2 Heterogeneity Analysis

To explore whether the relationship between patient capital and disruptive technological innovation varies across different firm characteristics, Table 2 presents a series of heterogeneity analyses based on ownership structure, financing conditions, firm size, and industry technology intensity. Each specification includes the same set of control variables as in the benchmark regressions, along with firm and year fixed effects.

Columns (1) and (2) compare state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). The coefficient on patient capital is positive but statistically insignificant for SOEs, while it is positive and significant for non-SOEs. This contrast suggests that the association between patient capital and disruptive innovation is more pronounced among non-state-owned firms, which typically face stronger market discipline and greater reliance on external capital in their innovation decisions.

Columns (3) and (4) examine firms with different levels of financing constraints. The results show that patient capital is significantly associated with disruptive innovation among firms with lower financing constraints, whereas the coefficient is not statistically significant for firms facing higher financing constraints. This pattern indicates that the presence of patient capital is more likely to translate into disruptive innovation outcomes when firms operate in relatively less constrained financial environments.

Columns (5) and (6) present results for large and small firms. The positive and significant coefficient for large firms contrasts with the insignificant coefficient for small firms, suggesting that firm size conditions the relationship between patient capital and disruptive innovation. Larger firms may be better positioned to leverage long-term oriented capital due to their stronger resource base and greater capacity to absorb innovation-related risks.

Finally, columns (7) and (8) report results by industry technology intensity. The coefficient on patient capital is positive and significant for firms in high-technology industries, while it is smaller and statistically insignificant for firms in low-technology industries. This finding implies that patient capital is more strongly associated with disruptive innovation in technological environments where opportunities for technological discontinuities and knowledge recombination are more prevalent.

Table 2. Heterogeneity analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	DTI	DTI	DTI	DTI	DTI	DTI	DTI	DTI
	SOEs	Non-SOEs	High FC	Low FC	Large Size	Small Size	High Tech	Low Tech
PC	0.003	0.007**	0.003	0.006***	0.010***	-0.000	0.006**	0.003
	(1.50)	(2.33)	(0.96)	(2.66)	(3.22)	(-0.20)	(2.55)	(1.20)
Constant	-72.107***	-8.945	-92.370***	-94.012***	-30.370	-40.233***	-49.482***	-101.205***
	(-5.12)	(-0.66)	(-5.41)	(-3.12)	(-1.37)	(-3.33)	(-4.10)	(-2.80)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,364	6,833	6,508	6,689	5,913	7,284	8,950	4,247
R-squared	0.45	0.41	0.49	0.43	0.44	0.42	0.49	0.57

5 Conclusions and Suggestions

This study investigates the relationship between patient capital and firms' disruptive technological innovation using a panel of Chinese A-share listed firms from 2011 to 2023. By combining a dynamic theoretical framework with firm-level empirical analysis, the paper provides a structured examination of how the time orientation of capital is associated with firms' engagement in innovation activities characterized by long horizons and high uncertainty.

The empirical findings show that patient capital is positively associated with firms' disruptive technological innovation. This relationship holds for both disruptive invention patents and disruptive utility model patents, indicating that long-term oriented capital is related to firms' entry into new technological domains across different layers of technological activity. The results remain robust after controlling for firm characteristics, governance structures, operating performance, and unobserved firm- and time-specific heterogeneity.

The heterogeneity analysis further reveals that this positive association is not uniform across firms. The relationship between patient capital and disruptive innovation is stronger among non-state-owned firms, firms with lower financing constraints, larger firms, and firms operating in high-technology industries. These findings suggest that firm characteristics and technological environments condition the extent to which patient capital is associated with disruptive innovation outcomes, rather than implying a uniform effect across all firms.

Rather than conducting explicit mechanism tests, this study interprets the empirical results through a formal theoretical framework that emphasizes intertemporal decision-making and technological choice. By modeling patient capital as a higher discount factor, the analysis clarifies how differences in capital patience affect the relative attractiveness of incremental versus disruptive innovation strategies. This theoretical perspective provides a consistent explanation for the observed empirical regularities and highlights the role of capital time orientation in shaping the direction of technological innovation.

From a broader perspective, the findings have important implications for policymakers and investors concerned with long-term technological development. Policies that encourage stable, long-term investment horizons and mitigate excessive short-term performance pressures may help create conditions under which firms are more willing to undertake disruptive innovation. For investors, the results underscore the potential strategic role of patient capital in supporting firms' long-term technological transformation, particularly in technology-intensive sectors.

Several limitations of this study should be acknowledged. First, the empirical analysis documents robust associations but does not seek to establish causal mechanisms through intermediary variables. Second, the identification of disruptive innovation relies on patent-based measures, which may not fully capture non-patented or organizational forms of technological disruption. Third, the focus on publicly listed firms may limit the generalizability of the findings to private firms or other institutional contexts. These limitations point to future research opportunities, including the use of alternative innovation measures, case-based approaches, and analyses in different institutional environments.

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