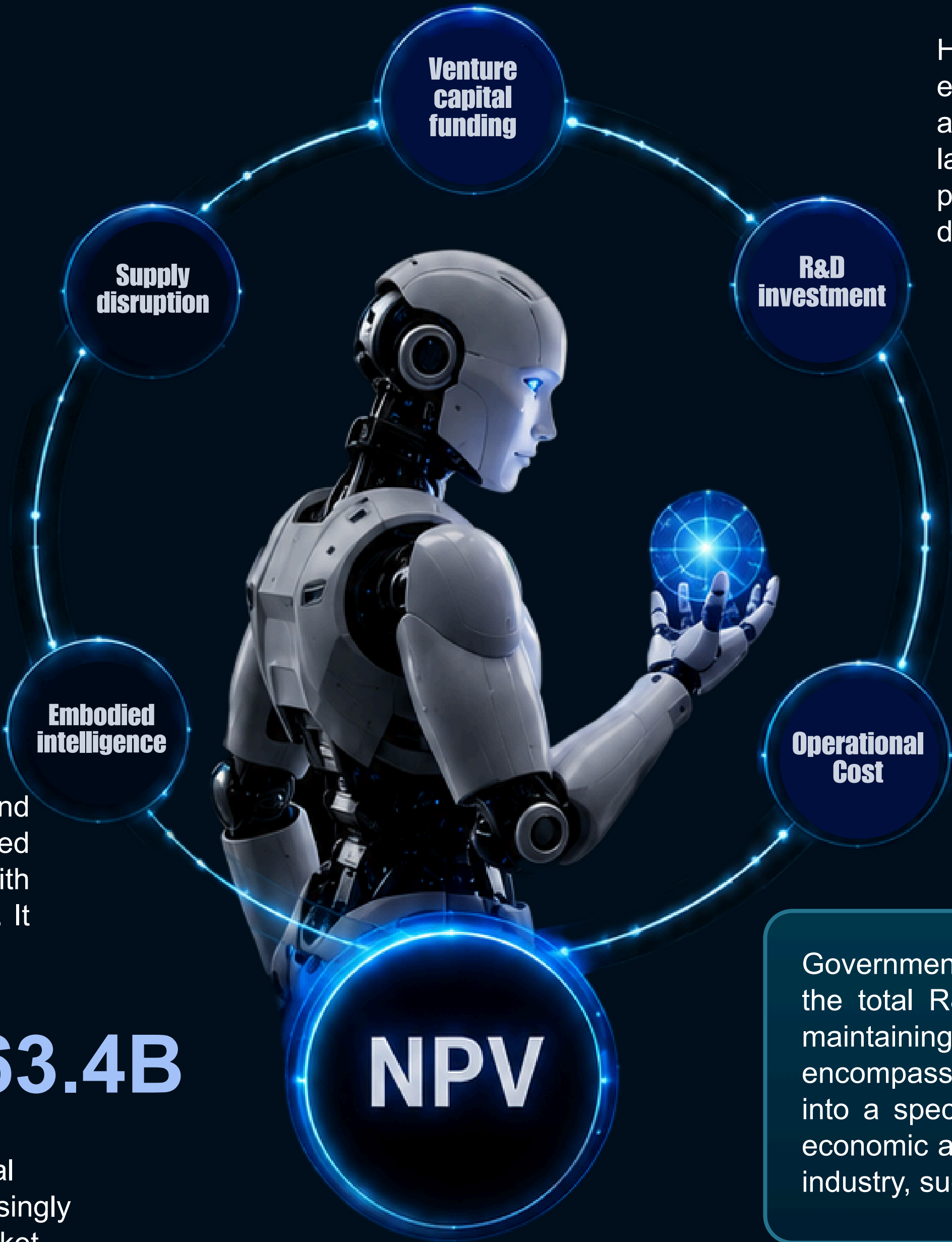


The Impact of Venture Capital, R&D Investment, and Supply Disruption on Embodied Intelligence Industry Financing

Shenzhen Middle School | Yanning Liu



Introduction

Currently, embodied intelligence serves as an emerging and rapidly growing industry. As defined in the literature, embodied intelligence is an AI-enabled physical system that interacts with the real world through perception, decision-making, and action. It covers fields such as robotics, autonomous vehicles, and UAVs.



¥863.4B

NPV



In China, this industry is closely tied to national policy, which means the government is increasingly focusing on its development. In 2024, the market size reached 863.4 billion yuan.

However, this high-tech industry requires substantial capital. The R&D costs are exceedingly high, as the products depend on core components and specialized algorithms. Specifically, in China, the industry is heavily dependent on imports and lacks localization. Moreover, the industry incurs additional costs from cloud platforms needed to support the products. In addition, the problem of supply disruption is particularly severe, especially regarding shortages of scarce elements.

How to solve

The most effective approach is to provide the industry with capital through financing strategies, which require large amounts, frequent rounds, and support from major companies. For instance, JD.com invested in six embodied intelligence enterprises within three months, covering a broad range with a total amount exceeding \$4 billion. Specifically, there are three main financing strategies: equity, debt, and pre-sale financing.

The core focus of this study is: under the circumstances of supply disruption, government influence, and operational costs, how can a company in the embodied intelligence industry make the optimal decision on financing strategies? Ultimately, an analytical model will be established. Within this framework, enterprises incur costs and bear various types of losses. Supply disruptions may originate from international disputes, transportation accidents, or disruptions in import processes.

Government influence includes subsidies, such as subsidies for the R&D process per unit, the total R&D cost, and subsidies for investors. Operational costs include the cost of maintaining online servers and payments for tokens. Although existing literature encompasses research on supply chains and financing, this study offers deeper insights into a specific domain: the industry of embodied intelligence. The objective is to apply economic and financing models to resolve the challenges confronted by enterprises in the industry, such as supply chain disruptions and financing constraints.

Literature Review

Existing literature examines three relevant streams. Venture capital studies focus on how VC fills financing gaps for startups and mitigates information asymmetry (Zider, 1998; Amit et al., 1998; Cochrane, 2005). R&D investment research shows that R&D enhances supply chain resilience under disruption, though effectiveness varies by disruption type (Parast, 2020; Ketelaars et al., 2025). Supply disruption studies **explore backup suppliers, dynamic pricing, and government subsidies** (Hou et al., 2010; Guo et al., 2021; Ivanov, 2024). However, few studies integrate VC, R&D, and disruption risk in a robotics-specific, capital-constrained supply chain. This paper bridges that gap by comparing own-fund, equity, debt, and pre-sale financing under disruption probability.

Assumption

The risk of supply chain disruption follows a Poisson distribution
Demand increases with R&D effort and market readiness
Supply disruption raises procurement or fulfillment cost
Policy support lowers R&D burden
The break-even condition is defined by $NPV = 0$

Model

Variable

λ : The average number of supply chain disruptions within a unit of time
 D : Basic market demand
 Δ : Subsidy ratio coefficient
 k : Manufacturer's operating cost coefficient
 φ : Manufacturer's level of operational effort
 e_m : Manufacturer's level of R&D effort
 e_{s1} : Supplier 1's level of R&D effort
 e_{s2} : Supplier 2's level of R&D effort
 a : Basic sale level, $a \in (0, t)$
 α_s : Share of profit to the investors
 a_0 : The number of sales increases per unit of level of effort (both R&D and operational)

Formula

Probability of uninterrupted supply:

$$P(N = 0) = e^{-\lambda}$$

Probability of supply disruption:

$$P(N \geq 1) = 1 - e^{-\lambda}$$

Inverse demand function:

$$p = a + (e_m + \varphi) a_0 + e^{-\lambda} e_{s1} a_0 + (1 - e^{-\lambda}) e_{s2} a_0 - q$$

The profit function and the final calculated NPV are listed below

Methods

This study aims to develop a model for an embodied intelligence company facing **potential financial shortages** and supply disruptions, while considering government subsidies for total R&D costs and the enterprise's operating costs. In this context, the government provides policy support through subsidies.

One manufacturer, one major supplier, one emergency supplier, one investor, and government support

Manufacturer: Financing constraints, R&D expenditure, Supply disruption, and operating cost

Operating cost: $\frac{1}{2}k\varphi^2$ (k Operating cost coefficient; φ Operational level)

Benchmark: Own Funds Model

$$\pi_1(e_m, q, \varphi) = pq - e^{-\lambda} \omega_{s1} q - (1 - e^{-\lambda}) \omega_{s2} q - \frac{(1 - \Delta) e_m^2}{2\theta} - \frac{1}{2} k \varphi^2$$
$$NPV_1 = \frac{(t - \bar{a})^3}{6t \left(2 - \frac{a_0^2 \theta}{1 - \Delta} - \frac{a_0^2}{k} \right)} - C_1$$

Equity Financing Model

$$\pi_2(e_m, q, \varphi) = (1 - \alpha_s) \left[pq - e^{-\lambda} \omega_{s1} q - (1 - e^{-\lambda}) \omega_{s2} q - \frac{(1 - \Delta) e_m^2}{2\theta} - \frac{1}{2} k \varphi^2 \right]$$
$$NPV_2 = \frac{\alpha_s (t - \bar{a})^3}{6t \left(2 - \frac{a_0^2 \theta}{1 - \Delta} - \frac{a_0^2}{k} \right)} - C_2$$

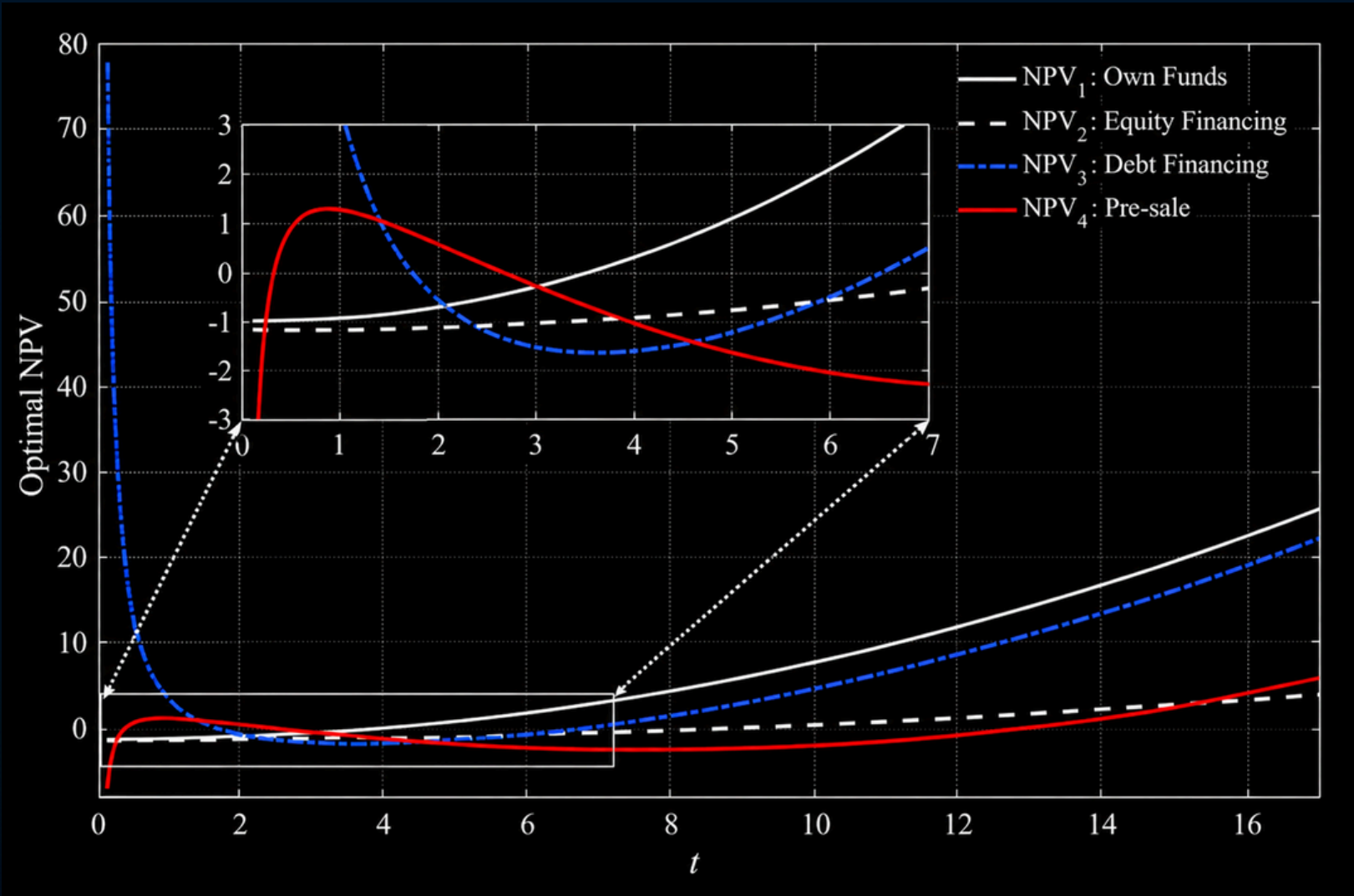
Debt Financing Model

$$\pi_3(e_m, q, \varphi) = pq - e^{-\lambda} \omega_{s1} q - (1 - e^{-\lambda}) \omega_{s2} q - \frac{(1 - \Delta) e_m^2}{2\theta} - \frac{1}{2} k \varphi^2 - D$$
$$NPV_3 = \frac{(t - \bar{a})^3}{6t \left(2 - \frac{a_0^2 \theta}{1 - \Delta} - \frac{a_0^2}{k} \right)} - \frac{D(t - \bar{a})}{t} + \frac{\sqrt{2(2 - a_0^2 \theta)} D^{\frac{3}{2}}}{3t}$$

Pre-sale Model

$$\pi_4(e_m, q, \varphi) = p(q - l) - e^{-\lambda} \omega_{s1} q - (1 - e^{-\lambda}) \omega_{s2} q - \frac{(1 - \Delta) e_m^2}{2\theta} - \frac{1}{2} k \varphi^2$$
$$NPV_4 = \frac{(t - \bar{a} - l)^3 + l^3}{6t \left(2 - \frac{a_0^2 \theta}{1 - \Delta} - \frac{a_0^2}{k} \right)} - \frac{l[\lambda \omega_{s1} + (1 - \lambda) \omega_{s2}](t - \bar{a})}{t} - C_4$$

Results



This figure shows that all NPVs increase with the market size ceiling t . At low t , heterogeneous financing mechanisms generate frequent intersections, indicating no dominant strategy. As t increases, financing constraints gradually weaken and the rankings stabilize.

Conclusion

This study investigates optimal financing choices for embodied intelligence enterprises under supply chain disruption and R&D investment. Equity financing, albeit diluting returns, effectively transfers downside risk; debt financing is viable only when market demand expectations are high or debt amounts are low; and pre-sale financing can substitute for external financing under specific threshold conditions. These strategies are mutually substitutable when corresponding parametric conditions are satisfied. R&D investment enhances supply chain resilience and mitigates disruption-induced losses. Government subsidies alleviate corporate financial pressure. Enterprises should flexibly select financing schemes contingent on market size and risk tolerance, while investors must ensure break-even conditions. The supply chain should endeavor to reduce disruption risks. This study provides quantitative decision-making references for relevant stakeholders, and future research may extend to complex scenarios such as mixed financing.

References

- [1] Amit R, Brander J, Zott C. Why do venture capital firms exist? Theory and Canadian evidence[J]. Journal of Business Venturing, 1998, 13(6): 441-466.
- [2] Alptekinoglu A, Bhandari A S, Sapra A. Demand management using responsive pricing and product variety to counter supply chain disruptions[J]. European Journal of Operational Research, 2024, 314(3): 867-881.
- [3] Davis-Sramek B, Germain R, Krotov K. Examining the process R&D investment-performance chain in supply chain operations: The effect of centralization[J]. International Journal of Production Economics, 2015, 167: 246-256.