Research on Collaborative Mechanism of Scenario Innovation in the Context of Digital Economy

Feng Men[1], Mian Wang[1*], Fangqi Dong[2]

[*]Corresponding author: wangmian@catarc.ac.cn

CATARC Automotive Industry Engineering

ABSTRACT: The scene has become the entrance and breakthrough of the future digital economy. Starting from the scenario innovation synergy model of "government setting up the stage, enterprises setting out questions, and enterprises answering questions", we build a three-party evolutionary game model, analyze the scenario innovation synergy mechanism, and find that the core of the scenario innovation synergy mechanism is the subjective initiative of the supply side. The government should improve the match between the supply and demand of the scenario, reduce the cost of scenario innovation, and enable the establishment of the scenario innovation mechanism.

Keywords: Digital economy, scenario innovation, synergy mechanism

1. INTRODUCTION

For a long time, China's scientific and technological innovation is mainly driven by technology. It follows the chain innovation model from basic research to technological breakthrough, product development, and market-oriented application, and lacks forward-looking and guiding design for national major strategies, high-quality industrial development, and organizational resilience. With the rapid development of the new generation of information technology, a large number of new scenarios, new species and new tracks have emerged, the speed of scientific and technological innovation has significantly accelerated, the integration of the demand side and the supply side has become increasingly close[2][4], and the traditional technology-driven innovation model is difficult to match the rapid changes in market demand, which restricts the development of the digital economy. At the same time, China's super-scale market advantages provide a broad and rich application scenario for the development of the digital economy. In this context, the model of promoting the development of digital economy through application scenario innovation is gradually emerging.

At present, scenario innovation has been highly concerned by the country, local governments and industry. Scenarios innovation in 2021 has been included in the National Fourteenth Five-Year Plan as an independent column. In 2022, the Ministry of Science and Technology, together with six departments, issued the Guiding Opinions on Accelerating Scene Innovation and Promoting High-level Application of AI to Promote High-quality Development of the Economy, which strengthened the overall guidance for the problems of inadequate understanding of AI scenario innovation, inadequate design of major scene systems, insufficient openness of scene opportunities, and imperfect scenario innovation ecology. At present, Shanghai, Beijing, Hefei, Chengdu and other cities have launched scene plans in

ICBBEM 2023, May 19-21, Hangzhou, People's Republic of China

DOI 10.4108/eai.19-5-2023.2334305

succession to promote scene innovation from the aspects of issuing lists, holding conferences, giving policies, demonstrating, drawing maps, and building systems. Innovative practices in the industry continue to emerge. Through continuous tracking and research on the scene practice of new species enterprises, Great Wall Strategy Consulting found that scenario innovation is active in the application fields of consumption, society, city, industry, digital infrastructure, and is closely related to the application of artificial intelligence, online, unmanned machines, cloud computing, advanced networks, virtual reality, future exploration, satellite technology and other technology groups[3].

Through the continuous practice of some provinces and cities, the scenario innovation has initially explored and formed a collaborative model of "government setting the stage, enterprises setting questions, and enterprises answering questions". The government has promoted the docking of scenario supply and demand with tools such as the scenario opportunity list. However, the necessity of government participation under this model and its impact on scenario innovation need to be further verified.

The purpose of this study is to study the scenario innovation mechanism under the participation of the government by building a three-party evolutionary game model, and provide theoretical reference for government policy formulation.

2. FORMATTING OF MANUSCRIPT COMPONENTS

2.1 The connotation of scene innovation

The Guiding Opinions on Accelerating Scenario Innovation and Promoting High-level Application of Artificial Intelligence to Promote High-quality Economic Development points out that scenario innovation is a process of achieving iterative upgrading of new technologies and rapid industrial growth, guided by the creative application of new technologies and taking the supply-demand linkage as the path. Scenario innovation has become an important mode of scientific and technological innovation in the new era. It not only stimulates the explosive growth of innovative enterprises, but also accelerates the continuous iteration and breakthrough of technology in scenario practice.

As shown in Table 1, there are significant differences between scenario innovation and traditional innovation models in terms of innovation motivation, innovation environment, innovation subject and innovation process[6]. In terms of innovation motive force, the scene innovation motive force has shifted from the subjective curiosity of scientists to the objective business demand[7]. In terms of innovation environment, the innovation environment moves from laboratory to real market environment. In terms of scene subjects, the innovation leaders have moved from scientific research institutes to scientific and technological innovation enterprises, and the participants have formed an innovation consortium from the scientific, industrial and investment circles. In terms of innovation process, the innovation process is concentrated in the real market verification environment, from the gradual innovation of research and development before transformation to the synchronous innovation of technology research and business transformation[5]. In summary, the scenario innovation model can fundamentally solve the problem of difficult transformation of scientific and technological achievements.

Table 1. Comparison between traditional innovation and scenario innovation.

Dimension	Traditional Innovation	Scenario Innovation
Innovation motive	subjective curiosity	objective business demands
Innovation environment	laboratory	market
Scene body	scientific research institutes	scientific and technological innovation enterprises
Innovation process	split innovation	synchronous innovation

As far as the result of scene innovation is concerned, there are essential differences between the innovative scene and the traditional scene at the levels of target, subject, object, space and elements, as shown in Table 2. At the goal level, the innovation scenario is oriented towards diversified, personalized and uncertain needs, with more emphasis on agility and empowerment. At the subject level, the subject of the innovation scenario extends from functional departments and supply chain enterprises to integrated teams and ecological partners. At the object level, the innovation scenario puts more emphasis on flexibility, self evolution and optimization, and focuses on the value chain/value network rather than the process. At the spatial level, the traditional scene takes physical space as the core, and more emphasis is placed on physical realization, while the innovative scene takes information physical space as the core, and more emphasis is placed on the combination of soft and hard, virtual and real interaction. At the element level, traditional scenarios take traditional elements as the core, and innovative scenarios take data as the core, with more emphasis on multi-element coordination and comprehensive optimization.

Table 2. Comparison between traditional and innovative scenarios.

Dimension	Traditional Scenarios	Innovation Scenarios
Target	Deterministic demand	Diversified, personalized and uncertain demands
subject	Functional departments and supply chain enterprises	Integrated team and ecological partner
Object	Process-centric	Value chain/value network as the core
Spatial	Physical space	Information physical space
Element	Traditional elements	data

2.2 Current situation of scenario innovation

At present, the rapid development of digital technology and the continuous expansion of application scenarios in China have laid a solid foundation for the innovation of digital technology scenarios[9]. However, there are still problems such as inadequate understanding of scene innovation, insufficient design of major scene systems, insufficient openness of scene opportunities, and imperfect scene innovation ecology. Therefore, in the short term, the mode

of "government setting the stage, enterprise setting questions, and enterprise answering questions" is still the main theme of scene innovation.

2.3 Scenario innovation mechanism

At present, the government mainly participates in scene innovation by giving opportunities and subsidies. The opportunities include publishing the list of scene opportunities, holding the scene docking conference, establishing the scene innovation system, etc. The subsidies include publishing demonstration application scenario projects, holding scene innovation competitions, etc.

Giving opportunities is to focus on the industry development, production and living needs, and release the supply and demand information to the society in the form of project-based, index-based and list-based expression of application scenarios, so as to make the scenario concrete into a perceptible, visible and participatory opportunity, and organically link the development needs and capabilities. Subsidy is to provide financial support to scene innovation enterprises from the perspective of the whole life cycle of scene innovation through roadshows, selection and cultivation, so as to reduce the investment cost of scene innovation entities and improve innovation enthusiasm.

Give opportunities to reduce the innovation costs of both supply and demand sides of scenario innovation: first, give opportunities to have a certain exemplary and leading role, which can reduce the costs required for both supply and demand sides to clarify the direction of innovation; Secondly, giving opportunities to promote the organic connection between demand and capability can reduce the cost of customer search on both sides. The subsidy directly affects the increase of the benefits of the scenario builder.

3. SCENARIO INNOVATION MODELING ANALYSIS

3.1 Model assumptions

(1) Participants and strategy selection

According to the analysis in the previous section and the stakeholder theory, this paper regards the scenario supply enterprise (scene party), the government, and the solution supply enterprise (technology party) as stakeholders, which are included in the scenario innovation transformation game system. The three parties can take "participation" and "non-participation" planning, and consider that the three parties are bounded rational individuals[1].

(2) Participation costs and benefits[8][10]

The inherent benefits of government participation and non-participation in scenario innovation are respectively R_1 、 R_4 , the inherent benefit of scenario party is R_2 , and the benefit of technology party is R_3 .

When the scenario party adopts the participation strategy, its scenario innovation investment intensity is p , and the basic investment of scenario innovation is C_{co} , so the scenario innovation cost of the scenario party is $(1+p)\ C_{co}$.

When the government adopts the participation strategy, the greater the input of scenario innovation, the smaller the cost of scenario innovation. Suppose that when the government's scenario innovation investment reaches the maximum value C_1, the scenario party's innovation cost reduction coefficient is m, and the technology party's innovation cost reduction coefficient is n. The technical party will invest a certain amount of cost C_3 when participating in the scenario innovation, so the costs of the scenario party and the technical party are respectively $(1-r*m)*(1+p)*C_{co}$、$(1-r*n)*C_3$, when the government intervention intensity is r. In addition, the government will grant subsidies G to the parties involved in the scenario innovation.

When the technical party does not participate in the scenario innovation, the scenario innovation cost is 0, and the matching degree between the supply and demand sides of the scenario is low, α is used to measure the matching degree of market supply and demand when the technical party chooses not to participate. When the technical party chooses to participate in the scenario innovation, $\alpha = 1$. The scenario innovation income of the scenario party, the government and the technology party is affected by the degree of synergy and openness α, and the conversion coefficients of the scenario party and the government investment are, k_1、k_2, that is, the three parties' income is, $k_1\alpha(1+p)C_{co}$, $k_2\alpha(1+p)C_{co}$、$\alpha(1+p)C_{co}$, respectively.

3.2 Income payment matrix

In the game model, it is assumed that the probability of the government participating in the digital transformation is x, the probability of the industry, university and research party participating in the digital transformation is y, and the probability of the user choosing strong dependence is z, $x, y, z \in [0,1]$. Based on the model assumptions, the following digital transformation payment matrix table 3 is obtained.

Table 3. Digital transformation payment matrix.

Strategy	Government	Scene party	Technology party
(p, p, p)	$R_1 + k_2M - rC_1 - G$	$R_2 + k_1M - (1-rm)M + G$	$R_3 + M - (1-rn)C_3$
(p, p, np)	$R_1 + k_2\alpha M - rC_1 - G$	$R_2 + k_1\alpha M - (1-rm)M + G$	$R_3 + \alpha M$
(p,np, p)	$R_1 - rC_1 - G$	R_2	$R_3 - (1-rn)C_3$
(p, np, np)	$R_1 - rC_1 - G$	R_2	R_3
(np, p, p)	$R_4 + k_2M$	$R_2 + k_1M - M$	$R_3 + M - C_3$
(np, p, np)	$R_4 + k_2\alpha M$	$R_2 + k_1\alpha M - M$	$R_3 + \alpha M$
(np, np, p)	R_4	R_2	$R_3 - (1-rn)C_3$
(np, np, np)	R_4	R_2	R_3

3.3 Model solving

According to the payment matrix, the expected income of government participation $E(x)$, non-participation $E(1-x)$ and average expected income $\overline{E}_g$ are obtained, Scenario party participation $E(y)$, non-participation $E(1-y)$ expected income, and average expected income $\overline{E}_e$, technical party participation $E(z)$, non-participation $E(1-z)$ expected income, and average expected income $\overline{E}_u$. From the income expectation function, the replication dynamic equations of the government, scenario party and technology party can be obtained as follows:

$$F(x)=\frac{dx}{dt}=x[E(x)-\overline{E}_g]=x(1-x)(R_1-rC_1-G-R_4)$$

$$F(y)=\frac{dy}{dt}=y[E(y)-\overline{E}_e]=y(1-y)\{x(rmM+G)+z(k_1M-k_1\alpha M)+(k_1\alpha M-M)\}$$

$$F(z)=\frac{dz}{dt}=z[E(z)-\overline{E}_u]=z(1-z)\{xyrnC_3+y[(1-\alpha)M-rnC_3]-(1-rn)C_3\}$$

Let $F(x)=F(y)=F(z)=0$ get the local equilibrium points as $E_1(0,0,0)$, $E_2(1,0,0)$, $E_3(0,1,0)$, $E_4(0,0,1)$, $E_5(0,1,1)$, $E_6(1,0,1)$, $E_7(1,1,0)$, $E_8(1,1,1)$.

According to the method proposed by Friedman (1991), the evolutionary stability strategy of the differential equation system can be obtained from the local stability analysis of the Jacobian matrix of the system, that is, the evolutionary stability point of the system is an equilibrium point that satisfies that all eigenvalues of the Jacobian matrix are non-positive. According to the copied dynamic equation, the Jacobian matrix of the system is as follows:

$$\begin{bmatrix} (1-2x)(R_1-rC_1-G-R_4) & 0 & 0 \\ y(1-y)(rmM+G) & (1-2y)\{x(rmM+G)+z(k_1M-k_1\alpha M)+(k_1\alpha M-M)\} & y(1-y)(k_1M-k_1\alpha M) \\ z(1-z)yrnC_3 & z(1-z)[xrnC_3+(1-\alpha)M] & (1-2z)\{xyrnC_3+y[(1-\alpha)M-rnC_3]-(1-rn)C_3\} \end{bmatrix}$$

Substitute 8 equilibrium points into the Jacobian matrix table 4, and obtain the corresponding eigenvalues of each equilibrium point.

Table 4. Digital transformation payment matrix.

Equilibrium point	Eigenvalue λ_1	Eigenvalue λ_2	Eigenvalue λ_3
(p, p, p)	$R_1-rC_1-G-R_4$	$(k_1\alpha-1)M$	$-(1-rn)C_3$
(p, p, np)	$-(R_1-rC_1-G-R_4)$	$(k_1\alpha-1+rm)M+G$	$(rn-1)C_3$
(p,np, p)	$R_1-rC_1-G-R_4$	$-(k_1\alpha-1)M$	$(1-\alpha)M-C_3$

(p, np, np)	$R_1 - rC_1 - G - R_4$	$k_1M - M$	$(1 - rn)\ C_3$
(np, p, p)	$R_1 - rC_1 - G - R_4$	$-(k_1M - M)$	$-[(1-\alpha)M - C_3]$
(np, p, np)	$-(R_1 - rC_1 - G - R_4)$	$(k_1 - 1 + rm)M + G$	$-(rn-1)C_3$
(np, np, p)	$-(R_1 - rC_1 - G - R_4)$	$-[(k_1\alpha - 1 + rm)M + G]$	$(1-\alpha)\ M - (1-rn)C_3$
(np, np, np)	$-(R_1 - rC_1 - G - R_4)$	$-[(k_1 - 1 + rm)M + G]$	$-[(1-\alpha)\ M - (1-rn)C_3]$

In order to facilitate the analysis of the positive and negative eigenvalues and ensure the reality of the analysis logic, this paper considers that the benefits of the participation strategy selected by three parties are greater than the benefits of non-participation. Suppose that $M - C_3 - \alpha M > 0$ 、 $k_1 - 1 > 0$ 、 $R_1 - rC_1 - G - R_4 > 0$. Therefore, there are two possibilities for evolutionary game stability strategy, as shown in Table 5.

Scenario 1: $(k_1\alpha - 1 + rm)M + G < 0$ .When the government participates in the scenario innovation, the incremental benefit of the scenario innovation without the participation of the technology side is negative. At this time, the equilibrium point and the corresponding Jacobian matrix eigenvalues are both negative, and the system has two evolutionary stability strategies: (participating, not participating, not participating) and (participating, participating, participating).

Scenario 2: $(k_1\alpha - 1 + rm)M + G > 0$ .When the government participates in scenario innovation, the incremental benefit of scenario innovation is positive without the participation of the technology side. At this time, the eigenvalues of the Jacobian matrix corresponding to the equilibrium point are all negative, and the system has only one evolutionary stability strategy: (participation, participation, participation).

Table 5. Stability analysis of equilibrium point.

Equilibrium point	Scenario 1				Scenario 2			
	λ_1	λ_2	λ_3	stability	λ_1	λ_2	λ_3	stability
$E_1(0,0,0)$	+	-	-	Unstable point	+	+/-	-	Unstable point
$E_2(1,0,0)$	-	-	-	Stable point	-	+	-	Unstable point
$E_3(0,1,0)$	+	+	+	Saddle point	+	+/-	+	Saddle point
$E_4(0,0,1)$	+	+	+	Saddle point	+	+	+	Saddle point
$E_5(0,1,1)$	+	-	-	Unstable point	+	-	-	Unstable point
$E_6(1,0,1)$	-	+	+	Unstable point	-	+	+	Unstable point
$E_7(1,1,0)$	-	+	+	Unstable point	-	-	+	Unstable point
$E_8(1,1,1)$	-	-	-	Stable point	-	-	-	Stable point

On the whole, by comparing the above two situations, when the policy is involved, the scenario side recognizes the importance of scenario innovation. When the benefit of scenario innovation is greater than the cost after the practice of scenario innovation, the scenario innovation system will eventually become stable. In the context of government scenario risk sharing, the scenario side focuses on scenario innovation, carries out technical development and other investments, creates an innovative atmosphere, provides direction and application environment for the technical side's innovation investment, and then participates in the scenario innovation process.

According to the symbolic analysis of $(k_1\alpha - 1 + rm)M + G$, the government can influence the innovation income of the scenario party by adjusting the degree of collaboration and openness, setting the intensity of the scenario innovation investment as, and the reduction coefficient of the scenario party's innovation cost as. The government should anchor two perspectives to promote the docking of scenario supply and demand and reduce the innovation costs of both parties, and implement relevant measures for scenario innovation.

4. MULTIMEDIA FIGURES – VIDEO AND AUDIO FILES

Compared with the traditional ways of promoting industrial development such as land, policy and capital, the application scenario has multiple functions such as providing new technology as a commercial application fulcrum, linking new products and market demand, and providing market to promote business model iteration. It is a composite carrier of experimental space, market demand and elastic policy. This study combines the current scenario innovation practice model, builds a three-party evolutionary game model, and analyzes the impact of government participation on the scenario innovation mechanism.

The modeling results show that the core of the scenario innovation synergy mechanism is the subjective initiative of the supply side. In the context of the government's scenario risk sharing, the scene side focuses on the scenario innovation and other investment in technology development, creates an innovation atmosphere, and provides the direction and application environment for the technical side's innovation investment. Only then can the scenario innovation mechanism with multiple participation be established. In order to improve the subjective initiative of the scene supply side, the following policy suggestions are put forward in combination with the model:

1) Improve the matching between supply and demand of scenarios. Guide the accurate identification of scenes through roadshows and other forms, promote technological exploration through policy incentives and other forms, and promote the docking of supply and demand through the list of opportunities, conferences and other forms.

2) Reduce the cost of scenario innovation. Develop basic service platform and scenario innovation tools, share innovation results, assist scenario modeling, and refine transformation path.

REFERENCES

[1] Zhong Xianxin. A scenario-oriented business architecture modeling approach based on ROADS[J]. J. University of Shanghai for Science and Technology,2022.

[2] Liu Jie. Scenario-innovation-driven AI and manufacturing integration mechanism[J]. New Economy Guide, 2022(3):8.

[3] Qian Lingxiao, Wang Liyan. Green scene innovation: building a digital driven development model[J]. Tsinghua Management Review, 2022(3):8.

[4] Yao Chenger. The core of scenario innovation is to achieve effective links[J]. Decision, 2022(12):1.

[5] Jiang Tao. Research on the transformation from production quality functional type to application scenario development under the background of digital economy[J]. Economic Management Research, 2022, 4(3):47-50.

[6] Sun Li, Guo Feng, Zou Bo. Digital driven scenario-based innovation[J]. Sales and management, 2021, 000(013):P.112-115.

[7] Yuan Puyu. Differentiate the value of enterprise architecture from the perspective of software development[J]. China Financial Computer, 2021(1):4.

[8] Xu Qiang. Deeply focus on scene innovation and promote the construction of industrial brain -- take the digital scene construction of "ten thousand mu and one hundred billion" new industrial platform as an example[J]. Information Construction, 2021(12):31-33.

[9] Yin Benzhen, Xing Liwen, Wang Yufeng. Scenario innovation drives the innovative development of digital economy[J]. Information Construction, 2020(8):2.

[10] Jiang Jihai, Liao Rui. Research on co-creation motivation and mechanism of scenario value in business model innovation[J]. Scientific and technological progress and countermeasures, 2017, 34(8):9.