Analysis of the Competitive Game of High-Speed Railway Technology on Non-equilibrium Technical Level

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Abstract. China's “go-global strategy” on high-speed rails is getting matured, but problems like technical standards and intellectual property rights are still major concerns. With the advancement of economic globalization and the rapid development of the information industry, competition in technical standards is becoming a new form of market competition. At present, China is still in a developing country, and there is still a certain gap between China and the developed countries, and its level of technical standards lags behind. This paper analyzes the manifestation of national interests in the dynamic game model, and it establishes a dynamic game model. It analyzes the national interests under different strategies, and analyzes the results of the game by decoding this model. It has concluded that the level of result of the competitive game of bullet train technology on non-equilibrium level lies on the quantification of intellectual property rights, and the size of the risk that each country needs to adopt for different strategies.

Introduction

Railway is the lifeline of a country's economy, and the high-speed railway is the embodiment of the national science and technology and the overall national strength. In recent years, China’s railway has achieved a leap-forward development. The railway technology has reached the international frontier. The entire railway industry chain has developed rapidly. Chinese railway has a complete technical system. It has mastered the production capacity of advanced technologies and multi-standard systems, and has accumulated a wealth of response complexities. The environmental railway operation experience has laid a solid foundation for the “go global” strategy.

Nowadays, the “High-speed Railway Diplomacy” has become a new visiting card for China and represents the comprehensive capabilities of technology integration, industrial support, major equipment, international financing, international trade, and international relations coordination. The “go-global” strategy of high-speed rails in China will promote the transition from “Made in China” to “Created in China”, bringing the Chinese standard to the world.

Nevertheless, China's high-speed rails are still facing problems like technical standards, intellectual property rights, and the political environment of the host country¹¹⁻¹². The certification and accreditation of dozens of countries along the “Belt and Road” development are uneven, being in trouble with multiple standards and different regulations. The inspection and certification mechanisms in various countries are so different that the cost in bilateral trade cooperation increases and certain difficulties emerge. With the advancement of economic globalization and the rapid development of the information industry, competitions in technical standards become a new form of market competition. China is still in a developing country at this stage, and how would the late-developed countries win the competition in technical standards becomes the focus of research.
Technical Standard Game

In ISO, technical standard is defined as “one or a series of documents with certain mandatory or guiding functions, and the content contains detailed technical requirements and related technical solutions, the purpose of which is to meet the security or quality requirements for related products or services. The essence of technical standard is the condition that must be in accordance with one or several production technologies.” Nowadays, technical standard is becoming the main barrier for trade protection in a country, and it is increasingly becoming the peak in industrial competition and being close to patent technology. It has become a key influential factor in exploring the international market.

At present, most studies on China’s “go global” strategy in high-speed railways focus on the the pros and cons compared with foreign countries and the improvement measures, etc. However, there is seldom researches on the game of technical standard competition. As the economic globalization surging, the importance of technical standard reveals, which might increase the competitiveness of enterprises and protect national interests. The setting of technical standards will directly affect the success of business operations and even the country’s competitiveness. Thus, it will become an important potential discourse power in the international division of labor and industry. The essence of competitions among enterprises lies on the competition for market initiative and control rights. Enterprises who formulate the standard can determine the industrial technological system and obtain huge benefits from it. Therefore, competition in key technical standards in important industries has been largely escalated into a game between countries based on politics, economy and even military power.

Analysis of Dynamic Game Strategy

Model Hypothesis

The model hypotheses of the dynamic game are as follows: International technical standards competition; standard competition on non-reciprocal technology level conditions; the model is a multi-stage dynamic game model; the player is a developer of technical standards in country A and a developer of technical standards in country B.

Two situations of technical standards competition: vertical competition—competition between old and new technical standards; horizontal competition—competition between different new technologies:

The process of game is divided into two phases:

In the first phase, the host country formulates policies: control, opening up (formulating the domestic host country's policy on other countries' technical standards)

In the second stage, the developer decides the direction of development: if there are many independent controllable intellectual properties, develop independently; if there is less independent controllable intellectual properties, cooperate with others.

Establishment of Model

Assume that there are two competing technical standards in the international market, the technical standards developed in country A and the technical standards developed in country B. First, the both countries formulate policies stipulating the technical standard for the entry of other countries. Then, the developer decides the direction of development based on the policies formulated by the both countries.

Analysis of Income of the Dynamic Game Model

When the standards of technology developers become national standards, their interests have been integrated into national interests. At this point, the country and the developer are seen as a whole.

(1) The economic interest is defined as: $e = f(N) + K$
f(N); means that national economic returns are related to the number of people using the technical standard.

K represents the benefits of the quantification of intellectual property.

N=N(u): indicates that the number of people using a technical standard is related to the utility of the technical standard.

Due to the existence of network utility, the influence of the increase in the number of people on the national economic interests should be a convex function, and the basic formula of product utility function can be written as: \( U = G + V \)

In the formula of network utility \( V = V(N) \), N represents the number of users. Assume that over a period of time, the longevity of products and consumers is long enough, new consumers continue to enter the market, and old consumers do not withdraw from the market. The entire formula indicates that the utility a certain technical standard can bring is the sum of individual utility and network utility.

The game model is a complete and perfect dynamic game of information. When the users enter the market in Phase I, they are familiar with the utility of technical standard A and B, which are called GA and GB, and the number of people in the previous phase \( N_{i-1} \). They have to consider what the users in the next phase would choose. Therefore, a dynamic game analysis method can be used to establish a complete and perfect dynamics game model of information. The usage of inverse inductive method can analyze the consumer's selection behavior in the final stage of the game and trace back to the previous phases until analyzing all of the phases.

For more convenient calculation, assume the technical standard in every phase is \( s(s = A_1, A_2, B_1, B_2) \), and the utility function will be \( U_s = G_s + V_s = G_s + V(N_s) \).

In which \( G_s \) and \( V_s \) indicates the single utility and network utility of the products with technical standard \( S \) in phase \( J \). \( N_s \) indicates the number of consumers using products with technical standard \( S \) in Phase \( J \).

(2) Safety utility is defined as: \( S = S(R) \). The risk coefficient \( R \) represents the risks arising from the policies and development directions adopted at home and abroad.

(3) Define the national economic and security as \( I = e*S = (f(N) + K)*S(R) \)

National interests include economic, security, political, cultural and diplomatic interests. In this paper, national interests are mainly economic and security interests because the other three are complicated and can be transformed into economic and security interests to some extent.

Dynamic Game Strategy Analysis

According to the analysis of national interest of Country A and Country B, when they choose different policies and developers, the economic and security interests are respectively

\[
I^A = e^A + K^A = f(P^A_n) = k(p_A, p_B; d_A, d_B) \quad ; \quad I^B = e^B * S^B = f(P^B_n) * S(R_B) = f(P^B_n) * S(P^B, P^A; d_B, d_A)
\]

As a leader, Country A has a developed technological standard. As a follower, Country B needs to develop a developed technological standard. B has two choices including independent development and following A’s technological standard. Therefore, when B adopts a following and compatible strategy, the intellectual property of A can bring economic interests to B as k (pA, pB; dA, dB), and the benefits are related to the policy and development orientation of Country B. The process of game between country A and B is worked out by the income analysis.
Model Solution

Analyze the procedure of game in accordance with inverse method.

The Subgame of the Third Stage: Country B Is the Decision Maker

1) Assume that in the first stage Country B adopts regulation policy, B’s strategy is that when Country A adopts regulation strategy, Country B should adopts independent development orientation; when Country A adopts open policy, Country B should adopt the development direction of following and compatibility. There are two Nash Equilibrium in this subgame: (regulation, independent development) or (open, following and compatibility).

2) Assuming that in the first stage Country B adopts open policy, the Nash Equilibrium of this subgame is (regulation, independent development) and (open, following and compatibility).

Subgame of the Second Stage

Through the above analysis, this paper simplified the game model. The benefits of the two countries are as follows:

Table 1. Profit values of Country A and B.

<table>
<thead>
<tr>
<th>Policies of Country A</th>
<th>Policies of Country B</th>
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<tbody>
<tr>
<td>Regulation</td>
<td>(A₁, B₁)</td>
</tr>
<tr>
<td>Open</td>
<td>(A₄, B₄)</td>
</tr>
</tbody>
</table>

Through analysis, A₅<A₈, B₁>B₅.

1) When A₁<A₄ and B₄<B₈, the only Nash Equilibrium of the model is (A₈,B₈), which means that both Country A and B are open, A adopts the development orientation of following and compatibility. In other words, when A choose the open policy, it can still gain enough benefits from intellectual property even if B adopts the regulation policy. What's more, when A adopts the open policy, B will bear great risks and have a low security factor if it choose the regulation policy.

2) When A₁<A₄ and B₄>B₈, the only Nash Equilibrium of the model is (A₄,B₄), which means that A adopts the open policy while B adopts the regulation policy and the development orientation of following and compatibility. In other words, when Country A is open, it can still receive enough benefits from intellectual property if Country B adopts the regulation policy. Besides, Country B bear relatively smaller risks when with regulation policy and the factor of security is controllable.

3) When A₁>A₄ and B₄>B₈, the only Nash Equilibrium of the model is (A₁,B₁), which means that both Country A and B adopt the regulation policy and Country B adopts the independent
development orientation. In other words, when A considers that it is having an open policy, it can not gain enough benefits from intellectual property if Country B adopts the regulation policy. In addition, when A adopts the open policy, the risks born by B when it adopts regulation policy are relatively smaller and the factor of security is controllable.

(4) When $A^1>A^4$ and $B^4<B^8$, there are two kinds of Nash Equilibrium including $(A^1,B^1)$ and $(A^8,B^8)$, which means that in one case, both Country A and B adopt the regulation policy and Country B adopts the independent development orientation. In the other case, both Country A and B adopt the open policy and Country B adopts the development orientation of following and compatibility. In other words, when A considers that it is having an open policy, it cannot obtain enough benefits from intellectual property if Country B adopts the regulation policy. Besides, when A adopts the open policy, the risks born by B when A adopts regulation policy are relatively higher and the factor of security relatively lower.

**Conclusion**

In case of a competition of technological standard of nonequivalent capability, competitor B can only strive to improve its own effectiveness so as to defeat the leader A. Otherwise, B can only develop its internet efficiency through the development strategy of following and compatibility. As a leading country of technological standard, Country A need to consider what strategy it should apply to Country B so that it can maximize its own benefits. It Country B adopts the development orientation of following and compatibility, A will benefit from Country B through quantization of intellectual property. If Country B adopts the regulation policy, A will bear certain risks. Therefore, the factors that determine the result of dynamic game model lie on the benefits of quantization of intellectual property and the magnitude of risks respectively born by the two countries that adopts different strategies.

In the competition of technological standard, the follower should analyze the risks that it need to bear under various strategies and take the right development orientation, adopting appropriate and reasonable policies to protect its own technological standard. As the leader, it should consider the measures taken by the follower and make rational policies, which not only help it obtain enough interests from intellectual property, but also cause no loss to its own country.

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**References**
