

A Tripartite Evolutionary Game Model for Chinese-Style Education Investment in ASEAN Under Local Government Policy

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ABSTRACT

With the deepening of the Belt and Road Initiative (BRI), many Chinese have been dispatched to Southeast Asian countries to participate in technical support and management. However, there are no OCE schools locally that can provide educational resources for their children. The decision of whether to invest in overseas Chinese-OCE has become a challenge for Chinese education groups. In this paper, the authors put forward an evolutionary game analysis scheme to study the OCE investment decisions among host country governments, students, and Chinese enterprises. The simulation results show that (1) the government's subsidy is always helpful to Chinese enterprise, especially at the beginning stage, (2) applying a soft strength of positive execution and combining with other methods could encourage the enterprise at the beginning and regulate the market later on, and (3) high strength of high support of government for the educational infrastructure is a win-win method for both students and the enterprise. Some managerial insights and suggestions are proposed based on these results.

KEYWORDS

Evolutionary Game, Government Regulation, Investment Decision, OCE

INTRODUCTION

With the advancement of the Belt and Road Initiative (BRI) proposed by General Secretary Jinping Xi in 2013, education and culture, as the core of “people-to-people bond,” play an important role. How to steadily promote the internationalization of culture and education has become an important topic. At the national level, as early as 2020, eight ministries and commissions, including the Ministry of Education, jointly issued the *Opinions on Accelerating and Expanding the Opening up of Education in the New Era* (Ministry of Education of the People's Republic of China, 2020) to provide Chinese programs for global governance in the fields of education and culture. In 2022, the State Council issued the *Development Action Plan for International Education Cooperation (2022-2025)* (People's

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Republic of China, 2022), which put forward specific requirements and plans for the overseas schools of OCE. It is planned that by 2025, there will be 1,000 China/foreign cooperatively-run schools and institutions. At the demand level, against the backdrop of global economic changes and the evolution of local economic patterns, China's position and role in the economic and trade system always reflects China's interaction with and leading capacity in globalization (Zhu et al., 2022). The proposal of the BRI reflects China's response to the changing world economic landscape and China's program for global economic governance. This initiative advocates inclusive global sustainable development. The spirit of "joint consultation, joint construction, and sharing" has been accepted by more and more countries, and China's program for economic globalization has had some positive impacts around the world (Huanqiu, 2023). According to relevant data from the Department of Outward Investment and Economic Cooperation of the Ministry of Commerce, from January to November 2021, China's non-financial direct investment in 57 countries along the Belt and Road reached 116.22 billion RMB, accounting for 18.1% of the total amount during the same period (Liu et al., 2017). In particular, direct investment in Southeast Asia exceeded \$16 billion (US) in 2020 (Ministry of Commerce of the People's Republic of China, 2021). Along with the influx of capital into Southeast Asia, a large number of Chinese engineers and managers have been sent there to help improve their job skills and management qualities. They are stationed there for 1-2 years and sometimes 5 or more years. Many engineers and managers started families in China before being dispatched. The long-term separation from family has become the primary concern for employees of Chinese enterprises who are reluctant to be stationed abroad. To this end, Chinese enterprises have introduced many security measures, such as paid leave, some reimbursement of round-trip air tickets for relatives, protection for accompanying children. These measures have alleviated the family difficulties of Chinese employees stationed abroad to some extent. However, the education for accompanying children remains a challenge. First, local education standards are different from Chinese education standards, and it is difficult for accompanying children to obtain authentic Chinese education experience. Second, the recognition system between local education and domestic education has not yet been established, and it is difficult for the results obtained by accompanying children locally to seamlessly connect with the domestic education system after returning home. Finally, IB courses locally are prohibitively expensive and not suitable for all expatriate employees. The recognition of IB courses in China still needs to be improved. In addition, with a large number of Chinese factories stationed locally, many locals need to improve their Chinese proficiency and understanding of Chinese culture in order to better communicate with Chinese managers and technicians to improve their own work skills. At present, local governments can only provide basic Chinese teaching institutions and a handful of Chinese schools funded by local Chinese. Even though Chinese schools can provide a certain level of Chinese cultural education, their teaching models and standards have long been integrated into the local context and cannot effectively solve the problem of OCE for local workers. To this end, Chinese education enterprises have begun investing in OCE schools in Southeast Asia to solve the aforementioned difficulties. However, investment in education is different from physical investment. It has characteristics such as long return cycle, slow effect, and obvious cultural attributes, particularity in overseas investment due to differences between countries in basic OCE. At the same time, the cultural label of education makes it difficult for SOEs or even state agencies to carry out similar direct investments locally, such as Confucius Institutes, on a large scale. Private enterprises with relatively flexible systems and methods are more suitable for promoting the implementation of OCE locally. Therefore, studying the models, strategies, and risks of overseas investment in OCE by private capital has profound practical significance and theoretical value in promoting cultural exchanges, knowledge sharing, and investment security between countries. Additionally, it is valuable to understand how the host governments' policy affects the investment in terms of subsidy, positive execution and the like. Especially in some ASEAN countries, a good policy does not always translate to better performance due to the flawed execution. Therefore, in this paper, host governments' actions are taken into account to make the model more reality. This paper organized the research structure followed by Wang & Li (2023).

LITERATURE REVIEW

This paper proposes a tripartite evolutionary game model to deal with the OCE investment issues. The research area in this paper contains educational foreign direct investment (FDI), Chinese style education investment, and evolutionary game theory. In this section, three related areas of literature on these fields are listed.

Current domestic and international scholars in the field of educational investment mainly have three research directions. The first category focuses on how FDI affects educational outcomes. These scholars pay close attention to post-investment benefits. Zhang (2017) and others found that increasing FDI in basic education in developing countries, especially East Asian countries, may have negative effects on higher education, while generating positive impacts on OECD and other developed countries. Through studying the relationship between FDI and local human capital costs, Muhammad (2018) discovered that FDI's effect on human capital formation demonstrates an inverted U-shape, meaning it has positive effects but with diminishing returns. The second group of scholars focuses on pre-investment preparations, trying to optimize investment behaviors by influencing contributing factors. Wang (2021) studied gender differences in education FDI, while Kuma (2013) examined the effectiveness of education investments in countries with varying development levels. They found that in developed countries, investing in basic education can facilitate technological advancement, especially in knowledge-intensive industries like telecommunications and software. However, for developing countries, educational investments in skills training are more conducive to promoting comparative advantages than basic education investments in labor-intensive sectors like textiles. The third group of scholars discusses overseas education investment models, issues, and challenges, attempting to optimize investment paradigms through top-level design of frameworks and institutions. Multiple scholars have researched cross-border education investment models in various countries (Lou & Yu, 2021; Han, 2019; Liu & Yang, 2019; Wang, 2018; Cun & Kong, 2022). Among them, Ma (2021) from Shanghai Normal University reviewed U.S. foreign education aid. By examining the providers, approaches, motivations and other aspects, she outlined the overall picture and provided suggestions for advancing Chinese education abroad, including improving the top-level design of international development cooperation agencies and strengthening information platforms for foreign education aid. Tan (2021), from the same university, discussed the business logic behind British international schools' history, models, strengths and weaknesses. Her research reveals that self-regulated organizations (mainly alliances formed by private schools) play a decisive role in promoting British education going global by formulating standards and supervision mechanisms.

Compared to research on foreign investment models, China's overseas education investment is still in its infancy and faces many challenges. Through comparing investments in vocational education, degree programs and basic education, Zheng (2022) found vocational education initiatives to be the most successful so far. However, there are almost no full-fledged Chinese international schools. Current Chinese education groups' overseas basic education investments concentrate on tutoring, while academic curricula mainly rely on collaborating with local partners to embed Chinese language programs, with the main content following local curricula rather than a completely parallel system. The main reasons for this are: 1) the Chinese government has not provided higher education pathways to compromise overseas Chinese education (Li, 2021) and 2) students interested in Chinese-style schools abroad are still predominantly Chinese descendants, rather than gaining the global influence of British education. To address these difficulties, some domestic scholars have proposed many innovative perspectives. Based on Shanghai's strong basic education, Li (2022) put forward four suggestions for government-led promotion of Chinese basic education going global: improving management regimes, promoting reasonable layouts and gradual progress, solving the "three teachings" issues, and optimizing fiscal safeguard mechanisms. Li (2021) analyzed the status quo of Chinese language education in Belt and Road countries and attributed the main driving force to local Chinese enterprises needing cultural identity among the labor force, thus stimulating locals to learn Chinese. Zheng (2021)

explored the motivations behind private Chinese universities' overseas expansion through mergers and acquisitions. In addition to capital gains, brand premiums and management benefits are also major incentives. With limited quality targets, competition will become increasingly fierce. In addition to qualitative analyses on overseas education investment, some international scholars have constructed quantitative models to simulate investment decision-making processes. Trappey and Charles (2007) incorporated risk preferences to weigh costs and used return uncertainties as factors to help financial holding groups reasonably assess risks and improve accuracy in international education investments.

In terms of methodology, this study focuses on the mechanism of investment among three players and the effect of each player's actions on the others. Therefore, game theory was chosen because it is an efficient decision making tool for dealing with the continuous actions taken by many players. Game theory was proposed over 100 years ago (Ammeltoft, 2013) and has been used in the decision-making field for over 70 years. In 1921, French mathematician E. Borel first used game theory in statistical optimization with the help of German mathematician J. Von Neumann (Von Neumann, 1928), and they finished the theoretical deduction. Von Neumann wrote his book on reviews of the game and economic behavior in 1944. However, by pushing game theory into worldwide use, Nobel Prize winner John Nash (1951), in his famous paper *Non-cooperative Games* and quantitative analysis- accessible method, Nash equilibrium, made the game applicable in reality. Smith (1976) put forward an evolutionary game to simulate his business rivals. Weibull (1997) focused on clarifying evolutionary game theory, in particular, the deterministic models of games. Wu et al. (2022) used evolutionary game theory to determine if LNG should replace the traditional ship for liner shipping. Zhang et al. (2023) applied a two-stage Stackelberg game to optimize the price of green vehicles, market shares, and optimal utilities of OEMs. He et al. (2023) enriched the knowledge hierarchy of Chinese Certified Emission Reduction (CCER) and provided important decision references for developing the CCER scheme in the carbon market based on tripartite evolutionary game model. Rafaela et al. (2023) revealed the impact of increasing carbon taxes and custom duties on polluting industries with game theory. Han et al. (2023) examined the impact of three governmental policies under different diffusion environments using game theory. Dharma (2006) explored equilibrium solutions to the government, and the opposition strategies in a political game.

In summary, most scholars in the education investment field concentrate their research on ex-post impacts and pre-investment considerations, while some discuss the overall frameworks and paradigms of game theory. However, these studies focus predominantly on foreign investment models, with very limited coverage of China's overseas education initiatives, especially in basic education. Also the previous researchers focused on the subsidies and policies. Few of them did research on execution strength and this factor is crucial in reality, especially in ASEAN since the area is undeveloped and bribery is prevalent there. Partly this is because Chinese overseas education investment has a short history without sample cases for reference. It is also partly attributable to China's rising international influence in recent years that has gradually brought Chinese culture and basic education onto the global stage, providing real-world foundations for research in this domain. Hence, this study will establish models of Chinese basic education overseas investment based on game theory and optimize the investment process. Also, this study offers the local government a framework to consider the relevant investment with policy tools.

MODEL

Relationships Among the Three Players

In this paper, there are three players: the host country government, Chinese enterprise, and students. The host country government should decide to execute positively or not. Chinese enterprise has two choices: investment or non-investment. There are two options for students: enrolling in an OCE school and enrolling in a traditional school. The relationships among each player are shown in figure 1.

Relationship Between Host Country Government and Enterprise

The enterprise is an investor and operator of the project. It has two strategies: investment and non-investment. The decision depends heavily on the governments' policy. Government is the market regulator. However, in most ASEAN countries, although governments publish many good policies, they still cannot be executed positively due to the law enforcement of government and humanity. The positive execution could guarantee the intended policy effects and formal regulation of the market. At the same time, a successful execution would increase the operational cost of Chinese enterprise because of the strict supervision and extra standards required at a local level. Therefore the local government should decide whether to execute positively to ensure the effect. Also, the government would need to subsidize the enterprise to attract them to invest since a good OCE environment would encourage Chinese capital development in the local areas.

Relationship Between Host Country Government and Students

The local government is responsible for providing students a quality education, and to that end, the local government must develop the educational infrastructure and improve the quality of education where needed. Therefore, when the OCE is introduced, some additional infrastructure and corresponding regulating rules should be established for the benefit of students. Students should decide on the kind of school they will enroll. Different types of schools provide different benefits. OCE schools, for example, teach basic learning skills and Chinese culture while placing students on the Chinese academic path and providing other benefits like opportunities for students at their preference of Chinese companies.

Relationship Between Chinese Enterprise and Students

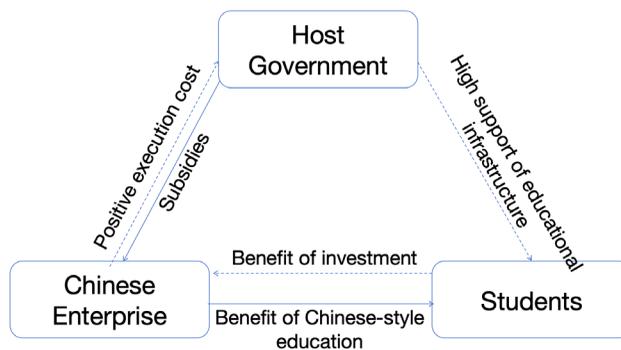
The relationship between the enterprise and students is a supply and demand pairing. Students who enroll in Chinese-style schools benefit from the additional facilities provided by the government and extra development for their future paths. In addition, Chinese companies spend money on R&D to establish their locations in new markets; this benefits students, employees, and the local communities.

Assumptions and Abbreviations

Since this research mainly focuses on Chinese enterprises' investment situations in One Belt One Road countries, especially Southeast Asian nations, the following basic assumptions need to be established before constructing the model:

- (1) The players in this game are all bounded rational individuals with incomplete information.
- (2) All players will determine their strategies dynamically throughout the process of the game.

Figure 1. Relationships between host government, Chinese enterprises, and students



- (3) Each player in the game has two possible strategies to choose from and chooses each strategy with a certain probability. That is, the host country government can choose either a *positive execution* or *negative execution*, representing the execution strength during the operation. The probability of choosing a positive execution is x , and the probability of choosing a negative execution is $1-x$. At the same time, the government will provide a subsidy to enterprise S_s , and the value of the subsidy is be represented by α . The enterprise will increase the cost of positive execution; therefore, positive execution cost C_g is an extra benefit from the government. The strength of execution is β . Also, in order to improve the local educational infrastructure and education quality for OCEs, additional cost S_g will be afford. λ represents the value of the infrastructure cost.
- (4) Chinese enterprises can choose either *investment* or *non-investment*. When enterprises choose to invest, they will receive the benefit of the operation of the school B_i . Before that, they will spend R&D cost C_r on OCE since this is a wholly new market. In addition to the direct benefit from operation, the benefit or cost from government also need to consider like subsidy, execution cost mentioned above. The probability of choosing investment is y , and the probability of non-investment is $1-y$. Regardless of the decision about the investment, enterprises will have expenses like due diligence, which are sunk costs, C_s .
- (5) Students can choose both Chinese-style and traditional schools. Due to the uniqueness of OCE services, students will gain B_c in the school. Students in the traditional school will gain B_t . The additional infrastructure funded by the government benefits students enrolled in OCE school – this is B_g . We assume the probability of students who enroll in OCE schools is z , and those who enroll in traditional schools is $1-z$. The abbreviations are shown in Table 1.

Table 1. Relevant parameters and meanings

Parameters	Descriptions
Government parameters	
α	Government subsidy or policies proportion
S_s	Government subsidy or policies
β	Positive execution cost proportion
C_g	Positive execution cost
λ	Government high support proportion
S_g	Additional costs of government's investment in supporting facilities and policies to students who enroll in OCE school.
x	Probability of positive execution of local government.
Enterprise Parameters	
B_i	Benefit of overseas OCE investment
C_r	R&D cost of Overseas OCE
C_s	Sunk cost for deciding whether to invest
y	Probability of investment in OCE school of Chinese enterprise.
Student Parameters	
B_t	The benefit of students who choose to study in traditional school.
B_g	Additional benefits of government's positive execution in operational level.
B_c	The benefit of students who choose to study in OCE school.
z	Probability of students enrolling in OCE school.

Payoffs for Each of the Players

Table 2 lists the payoff functions of each player when the assumptions are satisfied.

RESULTS

Stability Checking of Host Government

Assuming the expected payoff for the host country government with a *positive execution* is G_1 , the expected payoff with a *negative execution* is G_2 , and the average expected payoff is G_{12} , then:

$$G_1 = yz(-\alpha S_s + \beta C_g - \lambda S_g) + y(1-z)(-\alpha S_s + \beta C_g) + (1-y)z*0 + (1-y)(1-z)*0 \quad (1)$$

$$G_2 = yz(-\alpha S_s - \lambda S_g) + y(1-z)(-\alpha S_s) + (1-y)z*0 + (1-y)(1-z)*0 \quad (2)$$

$$G_{12} = xG_1 + (1-x)G_2 \quad (3)$$

According to the Malthusian replication dynamic principle, the replication dynamic equation for the government can be obtained as:

$$F(x) = \frac{dx}{dt} = x(G_1 - G_{12}) \quad (4)$$

$$F(x) = x(1-x)y\hat{a}C_g \quad (5)$$

A positive or negative execution strategy of government can be determined by seeking the partial derivative of dynamics equation $F(x)$ (Selten, 1988; Ritzberger & Weibull, 1995; Wainwright, 1989).

$$U'(x) = \frac{dF(x)}{dx} = (1-2x)y\hat{a}C_g \quad (6)$$

If the decision of the host government reaches stability, the condition $U'(x) < 0$ should be met. Then discussion of equation (6) is as follows:

Table 2. Payoff functions of three-party game

Game Strategies of Private Capital Overseas OCE Investment		Chinese Enterprises (P_e)			
		Investment		Not Investment	
		Student (P_s)		Student (P_s)	
		Enrollment in OCE School	Enrollment in Traditional School	Enrollment in OCE School	Enrollment in Traditional School
Host Country Government (P_g)	Positive execution	$-\alpha S_s + \beta C_g - \lambda S_g$	$-\alpha S_s + \beta C_g$	0	0
		$B_i + \alpha S_s - \beta C_g - C_r - C_s$	$\alpha S_s - \beta C_g - C_r - C_s$	$-C_s$	$-C_s$
		$B_c + B_g + \lambda S_g$	B_t	0	B_t
	Negative execution	$-\alpha S_s - \lambda S_g$	$-\alpha S_s$	0	0
		$B_i + \alpha S_s - C_r - C_s$	$\alpha S_s - C_r - C_s$	$-C_s$	$-C_s$
		$B_c + \lambda S_g$	B_t	0	B_t

(1) When $y = 0$, then $F(x) = 0$, it means for all x , the equation is always stable. Any strategy selected by the government would be the stable strategy.

(2) When $y \neq 0$, let $F(x) = 0$, $x = 0$ and $x = 1$ can be calculated. Since $0 < y \leq 1$, $\left. \frac{dF(x)}{dx} \right|_{x=1} < 0$,

$\left. \frac{dF(x)}{dx} \right|_{x=0} > 0$, in this case $x = 1$ is the global stable point, which means when Chinese enterprises select to invest in OCE schools, the optimal strategy of the host government is positive execution.

The evolution process of governments' decisions is shown in Figure 2.

Stability Checking of Chinese Enterprises

Assuming the expected benefit for Chinese enterprises with *OCE investment* decision is E_1 , with *non-investment in OCE* decision is E_2 , and the average expected benefit is E_{12} , then:

$$E_1 = xz(B_i + \alpha S_s - \beta C_g - C_r - C_s) + x(1-z)(\alpha S_s - \beta C_g - C_r - C_s) + (1-x)z(B_i + \alpha S_s - C_r - C_s) + (1-x)(1-z)(\alpha S_s - C_r - C_s) \quad (7)$$

$$E_2 = xz(-C_s) + x(1-z)(-C_s) + (1-x)z(-C_s) + (1-x)(1-z)(-C_s) \quad (8)$$

$$E_{12} = yE_1 + (1-y)E_2 \quad (9)$$

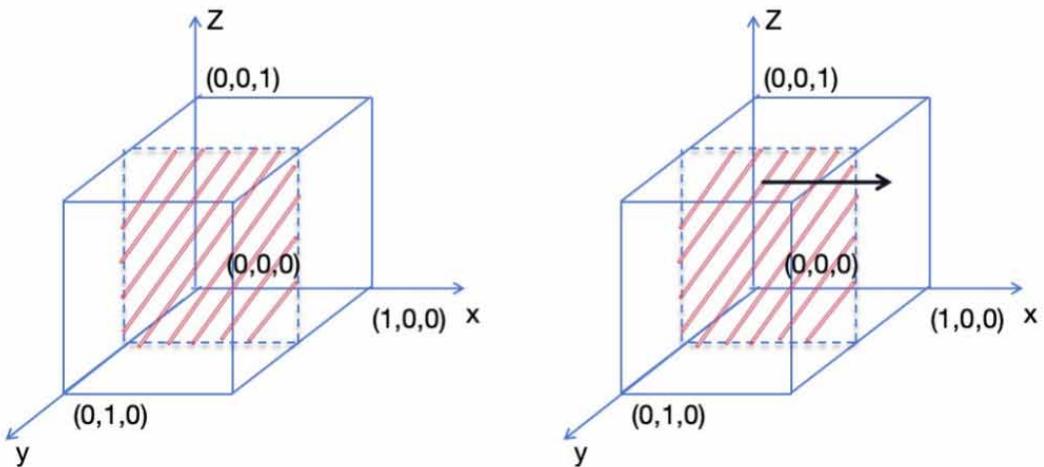
The replication dynamic equation for the Chinese enterprise can be obtained as:

$$F(y) = \frac{dy}{dt} = y(E_1 - E_{12}) \quad (10)$$

$$F(y) = y(1-y)(\alpha S_s - C_r - C_s + zB_i + xC_s - x\hat{\alpha}C_g) \quad (11)$$

Whether the Chinese enterprises invest or not can be determined by seeking the partial derivative of dynamics equation $F(y)$.

Figure 2. Evolution process of governments' decisions (a) $y = 0$, (b) $y \neq 0$



$$U'(y) = \frac{dF(y)}{dy} = (1 - 2y)(\hat{a}S_s - C_r - C_s + zB_i + xC_s - x\hat{a}C_g) \quad (12)$$

If the decision of the Chinese enterprises reaches stability, the condition $U'(y) < 0$ should be met. Then discussion of equation (12) is as follows:

(1) When $x = \frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$, then $F(y) = 0$, which means any option selected by the Chinese enterprises will be the stable strategy. Similarly, the probability of Chinese enterprises choosing to invest in OCE is stable when the probability of the host government's positive execution reaches $\frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$ or the probability of students choosing to enroll in OCE school reaches $\frac{x(\hat{a}C_g - C_s) - \hat{a}S_s + C_r + C_s}{B_i}$.

(2) When $x \neq \frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$, let $F(y) = 0$, then $y = 0$ and $y = 1$ will be calculated as the stable states, respectively. The two situations are considered below:

a) When $0 < x \leq \frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$, $\left. \frac{dF(y)}{dy} \right|_{y=1} < 0$, $\left. \frac{dF(y)}{dy} \right|_{y=0} > 0$ In this case $y = 1$ is the global stable point, which means when the probability of positive execution of the host government reaches a certain level, the best strategy for the Chinese enterprise is to start the OCE school investment.

b) When $\frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s} < x \leq 1$, $\left. \frac{dF(y)}{dy} \right|_{y=1} > 0$, $\left. \frac{dF(y)}{dy} \right|_{y=0} < 0$ In this case, $y = 0$ is the global stable point, which means when the positive execution of the host government is strict beyond a certain level, the best strategy for the Chinese enterprise is giving up their investment.

The evolution process of Chinese enterprises' decision is shown in Figure 3.

Stability Checking of Students

Assuming the expected payoff for the students with *enrollment in OCE school* decision is D_1 , with *enrollment in traditional school* decision is D_2 , and the average expected payoff is D_{12} , then:

$$D_1 = xy(B_c + B_g + \lambda S_g) + x(1-y)(B_c + \lambda S_g) + (1-x)y*0 + (1-x)(1-y)*0 \quad (13)$$

$$D_2 = xy(B_t) + x(1-y)(B_t) + (1-x)y*B_t + (1-x)(1-y)(B_t) \quad (14)$$

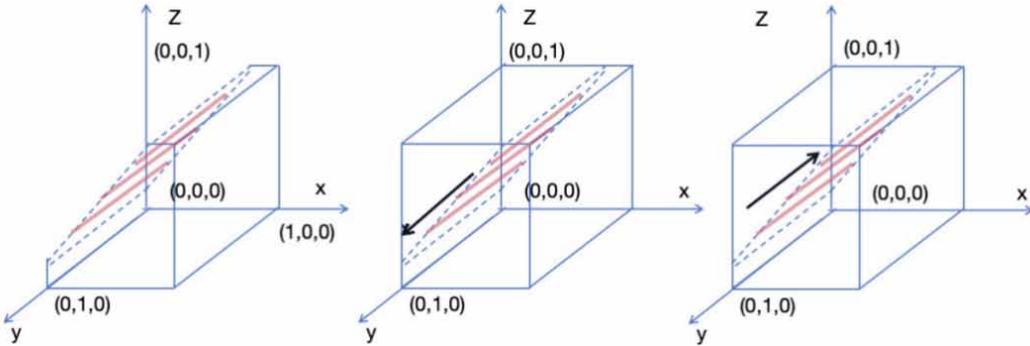
$$D_{12} = zD_1 + (1-z)D_2 \quad (15)$$

The replication dynamic equation for students can be obtained as:

$$F(z) = \frac{dz}{dt} = z(D_1 - D_{12}) \quad (16)$$

Figure 3. Evolution process of chinese enterprises' decisions (a) $x = \frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$, (b) $0 < x \leq$

$\frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s}$, (c) $\frac{\hat{a}S_s - C_r - C_s + zB_i}{\hat{a}C_g - C_s} < x \leq 1$



$$F(z) = z(1 - z)(xyB_g + x(B_c + \ddot{e}S_g) - B_t) \tag{17}$$

Whether the student enrolls in OCE school or not can be determined by seeking the partial derivative of dynamics equation $F(z)$.

$$U'(z) = \frac{dF(z)}{dz} = (1 - 2z)(xyB_g + x(B_c + \ddot{e}S_g) - B_t) \tag{18}$$

If the decision of students reaches stability, the condition $U'(z) < 0$ will be met. Then discussion of equation (18) is as follows:

(1) When $x = \frac{B_t}{yB_g + B_c + \ddot{e}S_g}$, then $F(z) = 0$, which means any option selected by the student will be the stable one. It also means that the probability of students to enroll in OCE schools is stable when the probability of host governments' positive execution reaches $\frac{B_t}{yB_g + B_c + \ddot{e}S_g}$ or the probability of Chinese enterprises choosing to invest in OCE schools reaches $\frac{B_t - x(B_c + \ddot{e}S_g)}{xB_g}$.

(2) When $x \neq \frac{B_t}{yB_g + B_c + \ddot{e}S_g}$, let $F(z) = 0$, then $z = 0$ and $z = 1$ are calculated as the stable states.

The two situations are considered below:

a) When $0 < x \leq \frac{B_t}{yB_g + B_c + \ddot{e}S_g}$, $\left. \frac{dF(z)}{dz} \right|_{z=1} > 0$, $\left. \frac{dF(z)}{dz} \right|_{z=0} < 0$ In this case $z = 0$ is the

global stable point, which means when the probability of positive execution of host governments reaches a certain level, the best strategy for students is to enroll in a traditional school.

- b) When $\frac{B_t}{yB_g + B_c + \ddot{e}S_g} < x \leq 1$, $\left. \frac{dF(z)}{dz} \right|_{z=1} < 0$, $\left. \frac{dF(z)}{dz} \right|_{z=0} > 0$ In this case $y = 1$ is the global stable point, which means when the positive execution of host governments is strict beyond a certain level, the best strategy for students is to enroll in an OCE school.

The evolution process of students' decisions is shown in Figure 4.

RESULTS ANALYSIS

To reveal the solution of the evolutionary game model, we solve the replication dynamic equations (5), (11), and (17) for the host country, Chinese enterprise, and students jointly to form the following 3D dynamic system:

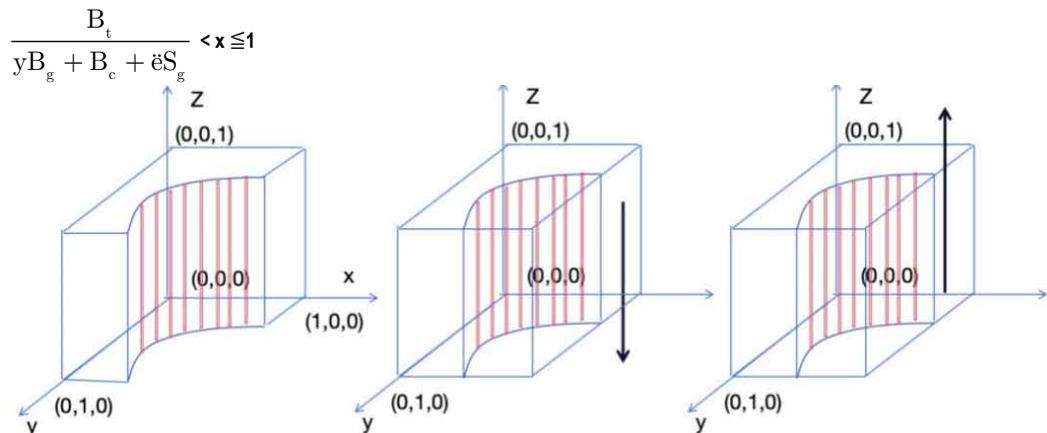
$$\begin{cases} F(x) = x(1-x)y\hat{a}C_g \\ F(y) = y(1-y)(\hat{a}S_s - C_r - C_s + zB_i + xC_s - x\hat{a}C_g) \\ F(z) = z(1-z)(xyB_g + x(B_c + \ddot{e}S_g) - B_t) \end{cases} \quad (19)$$

Let $F(x)$, $F(y)$, $F(z)$ equal 0. By solving the system of equations (19), we can obtain 8 pure strategy equilibrium points: $E_1(0,0,0)$, $E_2(1,0,0)$, $E_3(0,1,0)$, $E_4(0,0,1)$, $E_5(1,0,1)$, $E_6(1,1,0)$, $E_7(0,1,1)$, $E_8(1,1,1)$ and two mixed-strategy equilibrium points $E_9(\frac{B_t}{B_c + \ddot{e}S_g}, 0, \frac{-\hat{a}S_s + C_r + C_s}{B_i} - \frac{(C_s - \hat{a}C_g)B_t}{(B_c + \ddot{e}S_g)B_i})$ and $E_{10}(1, \frac{B_t - B_c - \ddot{e}S_g}{B_g}, \frac{-\hat{a}S_s + C_r + \hat{a}C_g}{B_i})$.

Determination of Stable Equilibrium Points

To determine whether an equilibrium point in evolutionary game theory is stable, we need to construct the Jacobian matrix and use the Lyapunov stability theory to analyze it. If the eigenvalues of the

Figure 4. Evolution process of students' decisions (a) $x = \frac{B_t}{yB_g + B_c + \ddot{e}S_g}$, (b) $0 < x \leq \frac{B_t}{yB_g + B_c + \ddot{e}S_g}$, (c)



Jacobian matrix evaluated at the equilibrium point are all positive, then the equilibrium point is unstable. If the eigenvalues are all negative, then the equilibrium point is stable. If the eigenvalues are mixed positive and negative, then the equilibrium point is also unstable.

To do this, this paper constructs the Jacobian matrix based on $F(x)$, $F(y)$, $F(z)$ as shown in (20):

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{bmatrix} \quad (20)$$

Taking $E_1(0,0,0)$ as an example, we can determine whether it is a stable equilibrium point. The stability analysis results for other equilibrium points are shown in Table 3. Substituting $E_1(0,0,0)$ into the Jacobian matrix (20), we can calculate the 3 eigenvalues: $e_1 = 0$, $e_2 = \hat{a}S_s - C_r - C_s$, $e_3 = -B_t < 0$, since $e_1 = 0$, one of the eigenvalues equal to 0. Then $E_1(0,0,0)$ is a center point.

Table 3. Eigenvalues and evolutionary stability of equilibrium points

Equilibrium Point	Eigenvalues	Stability of Evolution
$E_1(0,0,0)$	$\ddot{e}_1 = 0$	instability
	$\ddot{e}_2 = \hat{a}S_s - C_r - C_s$	
	$\ddot{e}_3 = -B_t$	
$E_2(1,0,0)$	$\ddot{e}_1 = 0$	instability
	$\ddot{e}_2 = \hat{a}S_s - C_r - \hat{a}C_g$	
	$\ddot{e}_3 = B_c - B_t + \ddot{e}S_g$	
$E_3(0,1,0)$	$\ddot{e}_1 = \hat{a}C_g$	instability
	$\ddot{e}_2 = -(\hat{a}S_s - C_r - C_s)$	
	$\ddot{e}_3 = -B_t$	
$E_4(0,0,1)$	$\ddot{e}_1 = 0$	instability
	$\ddot{e}_2 = \hat{a}S_s - C_r - C_s + B_i$	
	$\ddot{e}_3 = B_t$	

continued on following page

Table 3. Continued

Equilibrium Point	Eigenvalues	Stability of Evolution
$E_5(1,0,1)$	$\ddot{e}_1 = 0$	instability
	$\ddot{e}_2 = \hat{a}S_s - C_r - \hat{a}C_g + B_i$	
	$\ddot{e}_3 = B_t - \ddot{e}S_g - B_c$	
$E_6(1,1,0)$	$\ddot{e}_1 = -\hat{a}C_g$	Condition 1
	$\ddot{e}_2 = -(\hat{a}S_s - C_r - \hat{a}C_g)$	
	$\ddot{e}_3 = B_c + B_g - B_t + \ddot{e}S_g$	
$E_7(0,1,1)$	$\ddot{e}_1 = \hat{a}C_g$	instability
	$\ddot{e}_2 = -(\hat{a}S_s - C_r - C_s + B_i)$	
	$\ddot{e}_3 = B_t$	
$E_8(1,1,1)$	$\ddot{e}_1 = -\hat{a}C_g$	Condition 2
	$\ddot{e}_2 = -(\hat{a}S_s - C_r - \hat{a}C_g + B_i)$	
	$\ddot{e}_3 = -(B_c + B_g - B_t + \ddot{e}S_g)$	
$E_9(\frac{B_t}{B_c + \ddot{e}S_g}, 0, \frac{-\pm S_s + C_r + C_s}{B_i} - \frac{(C_s - \pm C_g)B_t}{(B_c + \ddot{e}S_g)B_i})$	$\ddot{e}_1 = 0$	instability
	$\ddot{e}_2 = 0$	
	$\ddot{e}_3 = 0$	
$E_{10}(1, \frac{B_t - B_c - \ddot{e}S_g}{B_g}, \frac{-\pm S_s + C_r + \pm C_g}{B_i})$	$\ddot{e}_1 = \frac{\hat{a}C_g (B_c - B_t + \ddot{e}S_g)}{B_g}$	instability
	$\ddot{e}_2 = -\ddot{E}_*$	
	$\ddot{e}_3 = \ddot{E}$	

*
 $\ddot{E} = \sqrt{x / B_i B_g}, x = (B_c - B_t + \ddot{e}S_g)(\hat{a}S_s - \hat{a}C_g - C_r)(B_c + B_g - B_t + \ddot{e}S_g)(\hat{a}S_s - C_r - \hat{a}C_g + B_i)$

Table 4. ESS conditions

NO.	ESS	Conditions
1	$E_6(1,1,0)$	$\hat{a}S_s - C_r - \hat{a}C_g > 0$
		$B_c + B_g - B_t + \hat{e}S_g < 0$
2	$E_8(1,1,1)$	$\hat{a}S_s + B_i > C_r + \hat{a}C_g$
		$B_c + B_g - B_t + \hat{e}S_g > 0$

Scenarios Analysis

Scenario 1

If $E_6(1,1,0)$ is an ESS, as shown in Table 4, then the condition 1 must be satisfied, which means $-(\hat{a}S_s - C_r - \hat{a}C_g) < 0$ and $B_c + B_g - B_t + \hat{e}S_g < 0$ should be met. This implies the host government deducts a high volume of subsidy, which would cover the R&D cost and positive execution cost of Chinese enterprises. Also, the benefit gained by students from traditional schools should be more than that gained from the sum of Chinese-style schools through the government investment. This situation generally happens at the beginning stage of the investment. Students do not yet realize the advantage of OCE schools, and governments trying to push this investment realize they will gain more benefit from other industries in China because local OCE schools will improve the Chinese business environment.

Scenario 2

If $E_8(1,1,1)$ is an ESS, then condition 2 is met, which means $\hat{a}S_s + B_i > C_r + \hat{a}C_g$ and $B_c + B_g - B_t + \hat{e}S_g > 0$ should be met. This indicates that the total benefit to students of Chinese-style schools should be more than that of traditional schools. At the same time, the revenue of Chinese enterprises including subsidies and benefits should be higher than the R&D cost of Chinese-style schools and the cost of positive execution. This situation happens at the later stage of investment, when students can gain more benefits from Chinese-style schools that attract them to enroll. Host governments should regulate the market and establish strict supervision policies when the cost of positive execution has increased. However, the cost of positive execution cannot be beyond the total profit of Chinese enterprise.

Considering the above two scenarios, in reality, only scenario 2 is possible. Because only the students choose to study in OCE, the investment will be success. Therefore, $E_8(1,1,1)$ is an ESS in reality, which we can confirm in the following section.

SIMULATION ANALYSIS

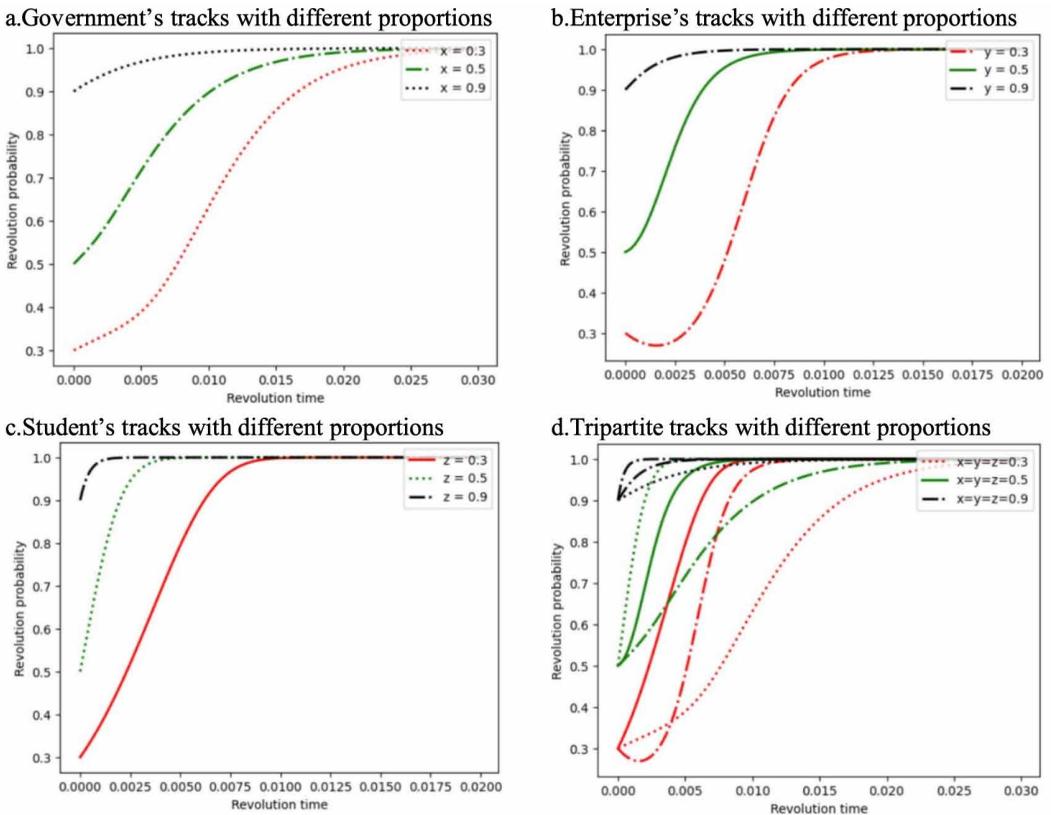
Using theoretical analysis, we employ Python to simulate the game model of Chinese enterprise, host government, and students, and the effects of some key factors are shown below.

Effect of the Initial Market Proportions of the Three Players

In this section, we deal with the evolutionary process at different initial market proportions. Let x, y, z represent the initial proportion of the host government, Chinese enterprise, and students. We start the simulation where x, y, z begin at 0.3, 0.5, and 0.9, respectively (Sun & Wan et al., 2020; Yang et al., 2020; Zhao et al., 2022). Therefore set the parameters as follows: $\alpha = 0.5, S_s = 500, C_g = 500, \beta = 0.5, \lambda = 0.5, S_g = 5000, B_i = 1500, C_r = 800, C_s = 10, B_t = 600, B_c = 400, B_g = 500$. The results are shown in Figure 5.

- (1) For the host government, positive execution is a very direct and effective way to regulate one industry. In the simulation, this conclusion is still satisfied. Regardless of the initial proportions of the host government choice, all of them will converge to positive execution in the end. Although the time cost is different, it will increase along with the increasing initial proportion of group of negative execution. However, when it starts at 0.3, the acceleration trend of the number of host governments with positive execution shows decreasing, increasing, and decreasing respectively, which means that governments still doubt the effectiveness of OCE. In the long term, host government tend to execute positively to make sure all the students will receive the available education.
- (2) Investing in the OCE school will be an optimal choice for Chinese enterprise later. As we can see from Figure 5b, regardless of the initial proportion of enterprise, they will finally converge to 1, which means when time goes on, the best strategy for Chinese enterprise is investment. And

Figure 5. Tracks with different proportions: a) government's tracks with different proportions, b) enterprise's tracks with different proportions, c) student's tracks with different proportions, d) tripartite tracks with different proportions



with the higher initial proportion of investment, the group of Chinese enterprises will reach an agreement in a shorter time. However, when it starts at 0.3, the number of Chinese enterprises selecting to invest decreases heavily at the beginning and then the number of Chinese enterprises turning back to invest increases dramatically. This situation shows that subsidies and the positive execution changes the investment environment. The increasing number of students who want to enroll in OCE schools promotes the investment as more attractive.

- (3) For students, the proportion of students who enroll in OCE schools increases without hesitation regardless of the initial proportion, though the converge time is different. The benefit of OCE schools is greater than that of traditional schools. Although there are some students who choose to enroll in traditional schools at the beginning, with the supporting policies and positive execution of government, the attraction of OCE schools is obvious in the long term.

Effect of the Influence of Other Factors

In this section, we select three parameters which are closely related to a host government's policy to reveal their impact on the players' decisions. The three variables are the government subsidy or policies proportion (α), positive execution cost proportion (β), and government high support proportion (λ). In section 5.1., we found the results of the evolutionary process would not be affected by the initial proportion of government support. Therefore, we set the initial proportions of each player at (0.5, 0.5, 0.5) in the following simulation.

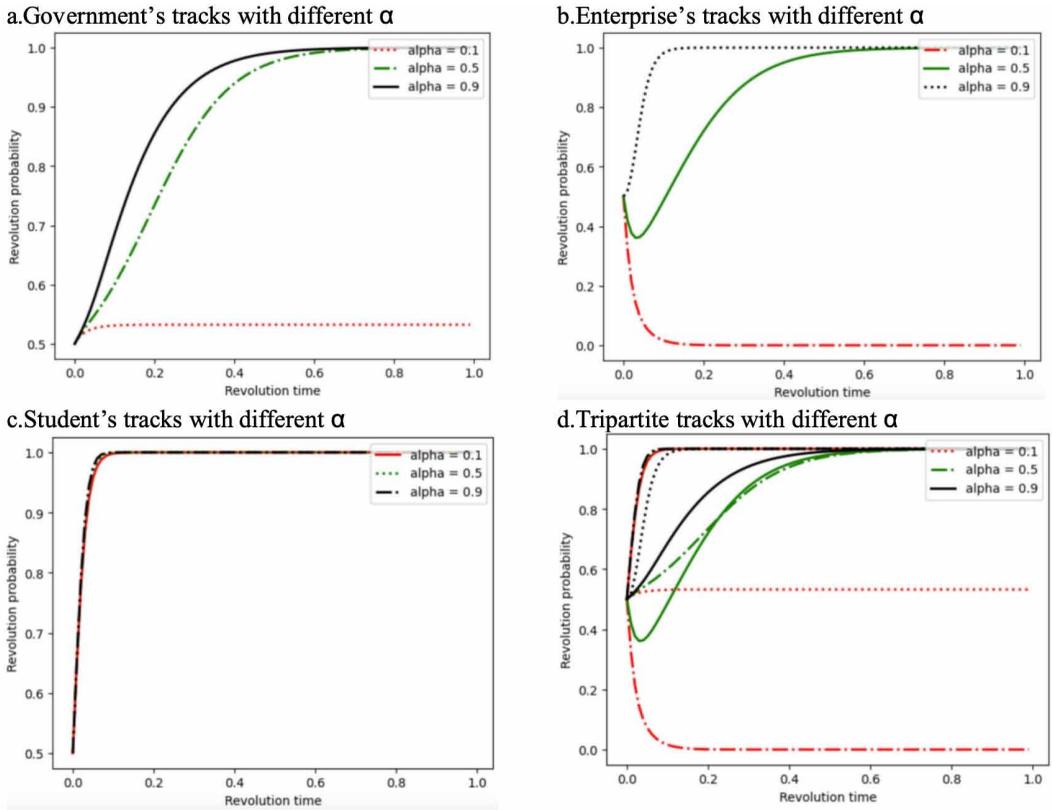
Analysis of Government Subsidy or Policies Proportions (α)

Assume that α is set to 0.1, 0.5 and 0.9, which means the low, medium and high intensity of subsidies, respectively. Then, the other fixed parameters are set as follows: $S_s = 100$, $C_g = 20$, $\beta = 0.5$, $\lambda = 0.5$, $S_g = 300$, $B_i = 100$, $C_r = 130$, $C_s = 10$, $B_t = 60$, $B_c = 40$, $B_g = 30$. The results are shown in Figure 6.

When the subsidy strength is low, enterprise intends to give up investment and eventually remain stable. Students are not affected by the subsidies' intensity. When the subsidy strength is high, enterprises evolve toward investing in OCE schools.

- (1) When the government's subsidy at a low level, government will not choose positive execution steadily. Since government does not promote a high level of subsidy, which means the cost to the government is low, the positive execution will decrease the benefit to enterprise and discourage them from investing in the project. However, the government will not choose the negative execution because the additional investment like educational infrastructure is already done. Basic regulation is needed. When the subsidy is at a medium or high level, the government will choose positive execution directly. The time cost from beginning to convergence decreases with the increasing subsidy. While the government is subsidizing with high expectation, it must regulate enterprise behavior and supervise the execution process. For the government, it would better to give a high subsidy at the beginning to regulate and diverse this market for a long term.
- (2) When the government's subsidy is at a low level, enterprise will choose non-investment for a short time. At the beginning, without a subsidy, an enterprise cannot easily promote the market. The high initial cost prevents the enterprise from future investment. When the government's subsidy rises to a medium level, enterprises will consider not investing at first, reaching the lowest point at 0.03. However, as time goes on, the market recognition improves and the benefit of OCE appears. Therefore, enterprises want to invest. When the subsidy reaches a high level, it will cover most risks. Enterprise will then choose to invest quickly.
- (3) The government's subsidy will not affect the benefit to students directly. Therefore, changing the subsidy level will not change the students' choice. They will choose OCE because of higher benefit of the school itself.

Figure 6. Tracks with different proportions of government subsidy or policy: a) government's tracks with different α , b) enterprise's tracks with different α , c) student's tracks with different α , d) tripartite tracks with different α



Analysis of Positive Execution Cost Proportions (β)

Assume that β is set to 0.1, 0.5 and 0.9, which means the low, medium and high intensity of positive execution cost, respectively. Then the cost of other fixed parameters is set as follows: $\alpha = 0.5$, $S_s = 100$, $C_g = 20$, $\lambda = 0.5$, $S_g = 300$, $B_i = 100$, $C_r = 130$, $C_s = 10$, $B_t = 60$, $B_c = 40$, $B_g = 30$. The results are shown in Figure 7.

The trend of the effect of positive execution cost is nearly the same for all players regardless of the value change. Both students and government benefit from positive execution since this is part of government's benefit and positive execution can provide a better education environment for students. But this is an additional cost to the Chinese enterprise, which influences the decision on the investment.

- (1) The government's attitude on positive execution is always the same, that is agreement. In Figure 7 we can see the difference along the increasing positive execution cost is the time that they reach a common understanding. The more positive law enforcement is, the shorter the convergence time, because when law enforcement is weak, which means the positive execution cost is small, the outcome of regulation is implicit. Government will not have enough evidence to support positive execution. However, when the cost of positive execution increases considerably, Chinese enterprise will take execution into consideration more seriously. This phenomenon will encourage governments to continue their execution.
- (2) To the Chinese enterprise, positive execution cost is always a burden. That is why at the beginning, Chinese enterprises tend to give up investment in all situations. However, accompanying the

positive execution in the long term, the standards, courses, and environment will be more suitable for local students, which will increase the profits to OCE schools in the long run. Therefore, Chinese enterprises will invest eventually. In Figure 7, we also see that the time cost of determining the investment is longest with the highest level of positive execution due to the balance between cost and benefit.

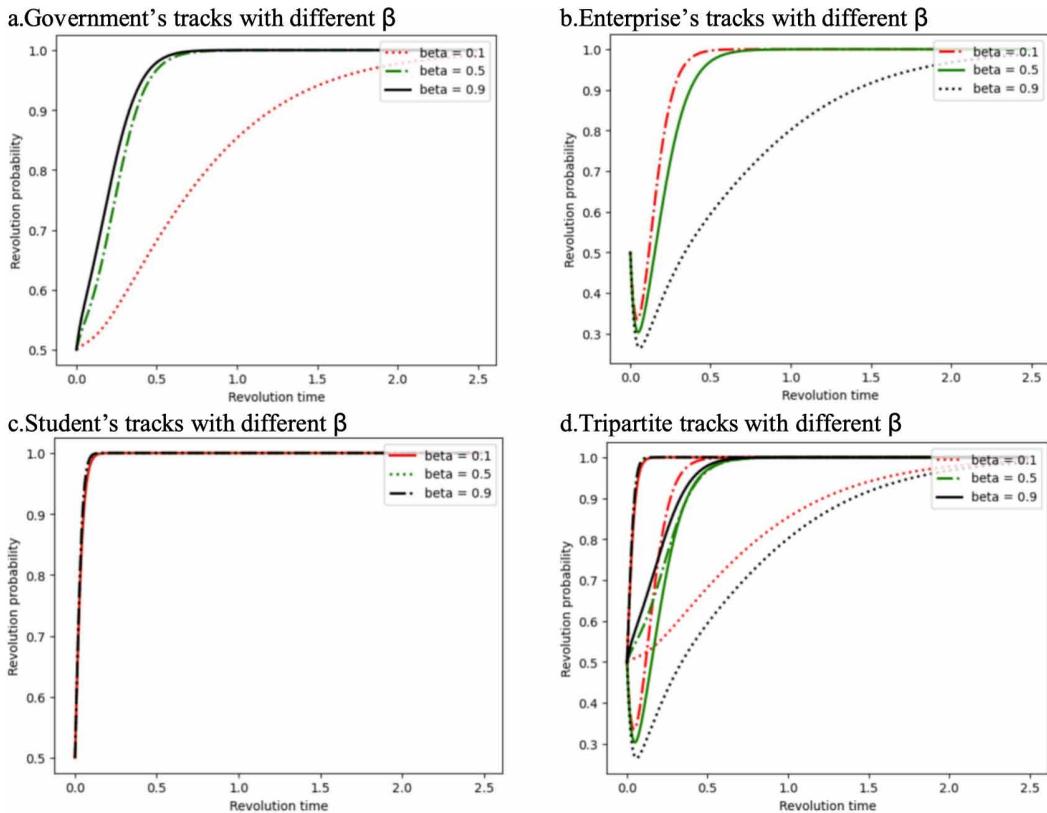
- (3) The government’s positive execution cannot affect the students directly. It will influence students’ decisions by regulating the OCE school and helping them be more attractive and encouraging students to enroll in Chinese-style schools. Therefore for all situations, students will choose to enroll in OCE schools with the government’s positive execution.

Analysis of Government High Proportion of Support (λ)

Assume that λ is set to 0.1, 0.5 and 0.9, which means low, medium, and high intensity of government high support, respectively. Then the other fixed parameters are set as follows: $\alpha = 0.5$, $S_s = 100$, $C_g = 20$, $\beta = 0.5$, $S_g = 300$, $B_i = 100$, $C_r = 130$, $C_s = 10$, $B_t = 60$, $B_c = 40$, $B_g = 30$. The results are shown in Figure 8.

The government’s high support policy is related to the educational infrastructure and the regional educational quality, which is close to students’ benefit. Therefore, it will influence the choice of students and affect the profit of enterprises. That is why for all players under different support enforcement, the tracks are different.

Figure 7. Tracks with different positive execution cost proportions: a) government’s tracks with different β , b) enterprise’s tracks with different β , c) student’s tracks with different β , d) tripartite tracks with different β



- (1) When the strength of government high support is medium and high, governments tend more toward positive execution with an increase in support strength. Low government support will decrease students' interest. The low entrance rate at Chinese-style schools will delay the investment of Chinese enterprise, which will also affect the proportion of government support. We can see when the strength of support is low, the pure strategy of positive execution cannot be reached. To regulate the market, government should provide more support at the beginning.
- (2) When the high support intensity is low, all Chinese enterprises choose not to invest in OCE schools. Due to the small market at the beginning stage and high R&D cost of the overseas OCEs, this investment cannot be profitable without a high level of support from the government. Although the benefit of high support does not directly affect the enterprise's revenue, the attraction of students will be affected heavily, especially at the beginning stage. The high support is also an endorsement of the pledge of enterprises, so students can make their decisions with more confidence. When the support increases, the proportion of enterprises that choose not to invest will initially increase. Eventually, enterprises will evolve towards the investment. Therefore, besides the subsidies, the support for students should also be sufficiently large to promote the investment. This provides value for governments, since the educational infrastructure can benefit the students for a long time and also improve the local education quality directly.
- (3) When the support strength is low, the proportion of students who choose to enroll in Chinese-style schools is low and quickly drops to 0. This directly results from the government's choice to decline support. When the support is high, students finally evolve toward enrolling in Chinese-style schools; the rate of evolution of students enrolling increases along with the increasing support from government. Then, governments should increase their strength of support to benefit more students and attract Chinese enterprises' investment.

THEORETICAL IMPLICATIONS

The background of this study is the culture exchange between ASEAN countries and China through OCE and the solution of missing OCE, which results in weakening of business environments in ASEAN countries, especially for Chinese enterprises. The theoretical implications of this study are indicated below.

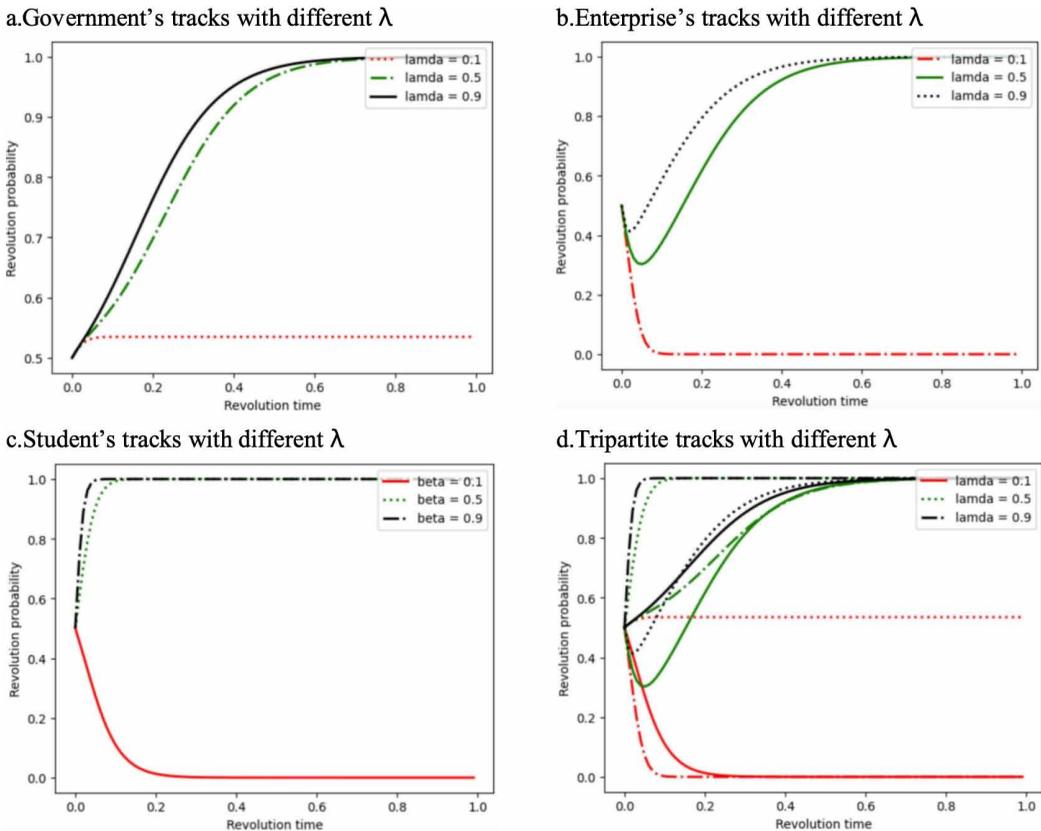
Theoretical Implications for Local Governments

- (1) This study uses the game theory approach to test the effects of three types of governmental strategies: execution, subsidies to overseas enterprises, and support to OCE education infrastructure. This study expands the theory of investment governance into the execution field, and this factor is quite crucial in ASEAN countries because of bribes. Also the mechanism of the three types of governmental strategies of OCE investment is revealed. For example, the efficiency of subsidy of government may be depend on the investment stage.
- (2) In terms of theory of foreign direct investment inflow (FDI) diversity in ASEAN countries and commerce environment improvement, this study offers local governments a new point of view on OCE investment and broadens the vision and ideas of the theoretical research of investment promotion.

Theoretical Implications for Chinese Education Enterprise

- (1) OCE is a new area of research since previously there has been no research related to overseas Chinese school investment. This research emerged as a result of the increasing number of Chinese

Figure 8. Tracks with different government high support proportions: a) government's tracks with different λ , b) enterprise's tracks with different λ , c) student's tracks with different λ , d) tripartite tracks with different λ



who work in ASEAN countries. Therefore, this research enriches body of knowledge in education investment theory.

- (2) This research also helps Chinese education enterprises to build their investment decision models. It illustrates the basic decision process of OCE investment, which constructs the fundamental model of this theory.

Theoretical Implications for the Model

Education is a special service whose benefit is indirect. It is similar to health care in that its infrastructure should be considered. Therefore, the government's support is a direct benefit to students rather than to enterprises. However, the improved educational infrastructure will also make online teaching at OCE more attractive, so there is indirect benefit. Also, the execution will increase the cost to the enterprise and the attraction of OCE, which benefits students at the same time. All these factors are considered in the theoretical model, expanding the theoretical implications for model.

PRACTICAL IMPLICATIONS

Practical Implications for Local Governments

- (1) In previous research, there is no relevant study on OCE investment. This study gives an outline of the effects of governmental strategies on OCE. It provides local governments a reference to understand the effects of OCE investment.
- (2) The simulation of this research helps local governments use their policy tools efficiently and also take into account combination strategies.

Practical Implications for Chinese Enterprise

- (1) This study helps Chinese enterprise to see the effects of investment in order to make a rational decision depending on local governments' policies.
- (2) This study is also like a basic guidebook of OCE investment for Chinese enterprise.

Practical Implications for Students

This study gives students a mechanism to choose which type of school to enroll.

CONCLUSIONS AND SUGGESTIONS

Conclusions

This paper investigates how local governments affect overseas Chinese-style education (OCE) investment with different governmental strategies. We put forward an evolutionary game theory analysis to study the OCE investment decisions among host country governments, students, and Chinese enterprises. Three governmental strategies were tested: subsidy, execution, and infrastructure support. In addition, three strength levels for each strategy were analyzed: high, middle and low. The results show that:

- (1) The initial proportion of each player will never affect the game result. The only affect is that the time of convergence will be delayed with the lower initial proportion, which is nature in reality.
- (2) Government subsidy policy will affect the existence of the investment heavily, especially at the beginning of the investment. Since OCE is a new educational model for local students, even for the children from China, this is essentially a localized new education system, and students need time to accept it. The high and medium strengths of government subsidy will help Chinese enterprises to decrease their cost at the beginning stages of investment. Especially with medium strength of subsidy, the probability of investment by Chinese enterprises decreases. With a low strength of subsidy, Chinese enterprises will not give up their investment.
- (3) The government positive execution is not welcomed at the beginning stage for enterprise at any strength level. However, it becomes popular in later stages since the positive execution will regulate the market and make OCE more attractive. It needs some time to be accepted. That is why with any level of positive execution, the decision evolution of enterprise forms a U shape as it moves from non-investment to investment.
- (4) For the high support of OCE, if the strength of high support is low at the beginning, students will never choose OCE schools, since without the endorsement of government, a new education system is unlikely to be accepted by local people initially. The educational infrastructure and policies for OCE schools are important to the students; therefore, the students and investment of Chinese enterprise will return with the increasing strength of high support of government.

Suggestions

There are three players in the game, and they are all affected by each other. Based on the results above, the following suggestions are made:

- (1) Host governments should clarify the effect of different methods and the mechanism of effects on Chinese enterprises and students based on the following three points.
 - a) The government's subsidy is always helpful to Chinese enterprise, especially at the beginning stage. For a new service or product like OCE, a subsidy will encourage investment if this service or product is valuable in the long term, and vice versa.
 - b) The government's positive execution strength should be selected carefully. It will not benefit the enterprise initially, but in the long run it will benefit the enterprise and market through regulation. Applying a suitable strength of positive execution and combining with other methods could encourage the enterprise at the beginning and regulate the market later.
 - c) High strength of high support from government for the educational infrastructure is a win-win for both students and enterprises. It will improve the education quality and attract more students, which results in benefits to the enterprise.
- (2) Chinese enterprises also should clarify how to develop the educational system to attract more students in the long run without the support of host governments.
 - a) In the process of investing in overseas Chinese education, Chinese enterprises need to adhere to the concepts of cultural and economic interconnections. While pursuing economic benefits, they should also promote local cultural diversity, actively connect with local Chinese enterprises, and build communication bridges between local students, schools, Chinese enterprises and mainland China. Relying on friendly Chinese culture, they can actively promote local cultural and educational development, and improve local youth's cultural literacy and life skills through advanced educational concepts and methods. This provides scientific and effective education solutions for local governments and local Chinese.

AUTHOR NOTE

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