Research on the Moderate Scale of 7-11 and Meiyijia, Based on Different Symbiosis Modes

--Taking Shanghai as An Example

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Abstract: In order to determine the appropriate scale of new retail stores of Japanese brands and Chinese local brands, promote the healthy development of the two types of convenience stores, and provide more convenient services for urban residents. First, based on the principle of co-evolution, 7-11 and Meiyijia are taken as representatives of two different types of convenience stores to establish Lotka-Volterra evolution models of them. Then, the stable points in the evolution model are determined according to the Jacobian matrix and assigned according to different co-evolution modes and stability conditions. Finally, numerical simulation is performed using data from these two stores in Shanghai. The results show that the evolution of 7-11 and Meiyijia is related to the symbiosis coefficient between them, and neither of them can reach their scale threshold in the competitive environment. However, both of them have larger development space and can reach their scale threshold in the mutualistic symbiosis environment. Therefore, it puts forward the suggestion that the two should strengthen cooperation and development to provide a more convenient life for residents.

Keywords: New retails store, Lotka-Volterra, Evolution, Symbiotic.

1 Introduction

With the continuous development of the economy, people's nightlife is becoming more and more common. Due to the limited service content and business hours, traditional retail stores can no longer meet the needs of consumers. Emerging new retail chain stores are gradually replacing traditional retail stores such as small street supermarkets and grocery stores [9]. Compared with traditional retail stores, emerging new retail chain stores have expanded business scope and extended business hours to provide convenience for people who work or play at night.

There are more and more brands of new retail chain stores, and the number of stores in a certain region is also gradually increasing. There is thus competition between different brand new retail stores, which includes new Japanese retail chains represented by 7-11 and new Chinese retail chains represented by Meiyijia. Therefore, what kind of development relationship between two

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new retail stores of different brands can provide better service for residents has become an urgent issue to be discussed.

2 Review of relevant literature

The research on new retail stores mainly focuses on marketing strategy and location choice of new retail stores, as well as the supply chain management of new retail stores [4]. From the perspective of new retail model, Liu taking H fresh e-commerce enterprise as the research object, conducted a cost analysis of production activities in each stage and revealed cost control problems in different stages [5]. In view of the problems existing in the supply chain KPI management of Chinese retail enterprises. Lin studied the distribution pattern and location selection mechanism of new retail space in China from the perspective of evolutionary theory [3].

The Lotka-Volterra model proposed by Lotka and Volterra in the 1940s has been used to analyze the dynamic competition between populations, and has been applied to the study of industrial development, organizational management and other issues [10]. In recent years, some scholars have applied this model to the innovation of economic management activities. Based on this model, Gao established the cooperation and competition model among members of a high-tech virtual industrial cluster, and analyzed and extended the model [1]. Li used Lotka-Volterra model to study the development trend of taxi and online hailing car under different modes of competition, cooperation and co-opetition [6]. Ning constructed Lotka-Volterra dynamic evolution model of digital innovation ecosystem with two and three objects, and studied the symbiotic evolution model of digital innovation ecosystem [7]. These results provide ideas for studying the symbiotic development mode of two different brand new retail stores.

Through the review of literature related to new retail stores and symbiotic evolution, it is found that, on the one hand, the existing literature has laid a relatively rich theoretical foundation for this paper, but on the other hand, there are still deficiencies in previous studies, which need to be further expanded and explored. Firstly, previous studies on new retail stores are based on location choice and profit analysis of new retail stores or the supply chain of new retail stores of one brand, while there are few studies on the appropriate scale of new retail stores of two brands. Secondly, the research based on Lotka-Volterra model also mainly focuses on the symbiotic relationship between industrial clusters and two kinds of book websites, without involving two kinds of new retail stores of different brands. Based on this, this paper uses Lotka-Volterra model and Matlab software to do a simulation analysis to determine the appropriate scale of new retail stores under different symbiosis modes, so as to promote the stable development of the industry and provide better services for people.

3 Model analysis

The hybrid research method is becoming a promising research method in management science [8]. In this study, model analysis and computer simulation analysis are adopted to deeply explore the symbiotic evolution of new retail stores of different brands. Besides, it is necessary to use the method of ecological evolution for reference to study the number, structure and overall evolution of the internal population because there is a certain complementary and competitive

relationship between new retail stores of different brands. According to ecology, the growth and change laws of the biological population are as follows: in a short period, the growth law of Malthus model is generally followed the population size increases exponentially [11]; With the increase of time, the population size gradually increases, and the influence of density restriction becomes more and more significant, forcing the population size to grow slowly and gradually reach saturation. It will show the Logistic growth law. Therefore, this paper firstly discusses the growth law of two new retail stores of different brands with the help of ecological Logistic equation. Because of the absence of numerous empirical time series data, numerical simulation is an effective empirical method. Meiyijia represented as the new local retail stores and 7-11 represented as Japanese new retail stores are important additions to the new retail stores in the city. The relationship between them also provides a certain basis for us to study the foreign investment of China's new retail stores in the future.

3.1 Co-evolution Model Construction

7-11 represents Japanese new retail stores, and Meiyijia represents Chinese local new retail stores. The development of these two brands has a strong interaction with the local economic and social development, and is based on a certain passenger flow, so the development scale of the two should be limited to a certain range by the local population density and economic status. Since the Logistic model can better reveal the development trend of new retail industry, this paper assumes that the development of 7-11 and Meiyijia is in line with the Logistic model, and their development scale is represented by their respective number of stores. The competitive evolution between 7-11 and Meiyijia can be analyzed using an improved Logistic model, the Lotka-Volterra model, which satisfies multiple systems.

Propose assumption: Hypothesis 1: The population number of the new retail stores of two brands is restricted by environmental factors such as resources and institutions. Like the growth process of the natural ecosystem, it needs to go through a process from infancy to extinction.

Hypothesis 2: The growth process of Meiyijia and 7-11 obeys the Logistic growth law.

Hypothesis 3: There is an interaction and mutual influence between the new retail stores of these two brands, and this influence is interactive.

Hypothesis 4: Both Meiyijia and 7-11 have constant size thresholds.

Model construction

$$\begin{aligned} \frac{\mathrm{d}X_1(\mathrm{t})}{dt} &= v_1 X_1(t)\left[1-\frac{X_1(t)}{M_1}-\lambda\frac{X_2(t)}{M_2}\right] \\ \frac{dX_2(t)}{dt} &= v_2 X_2(t)\left[1-\frac{X_2(t)}{M_2}-\theta\frac{X_1(t)}{M_1}\right] \end{aligned} \tag{1}$$

where $\frac{dX_1(t)}{dt}$, $\frac{dX_2(t)}{dt}$ respectively represent the growth rate of 7-11 and Meiyijia at time t, $X_1(t)$ and $X_2(t)$ respectively represent the number of stores of 7-11 and Meiyijia, which changes with time t and they are functions of time t. v_1 and v_2 respectively represent the fixed growth rate of the number of 7-11 and Meiyijia stores, assuming that they are constants greater than zero; M_1 and M_2 are the size thresholds of 7-11 and Meiyijia quantity under certain population density and economic development constraints, suppose its value is constant. λ represents the effect of Meiyijia on 7-11. If it is positive, Meiyijia has a negative effect on 7-11; if it is negative, Meiyijia has a positive effect on 7-11.

3.2 Stability Point Analysis

The population equilibrium point of the two different brands of new retail stores is different, and their stable state is also different. Reaching the equilibrium point means that the output of both sides reaches the maximum and remains stable. In a certain social environment, when time t approaches infinity, the above two equations satisfy: $\frac{dX_1(t)}{dt}=0$, $\frac{dX_2(t)}{dt}=0$. 7-11 and Meiyijia meet the symbiosis and evolve to a stable state. At this time, the number of stores in 7-11 and Meiyijia are X_1^* and X_2^* respectively, and four stable points can be obtained: N_1 (0, 0), N_2 (0, M_2), N_3 (M_1, 0) and N_4 $\left(\frac{M_1(1-\lambda)}{1-\lambda\theta},\frac{M_2(1-\theta)}{1-\lambda\theta}\right)$. The stability of the four equilibrium points can be judged by Jacobian matrix. If $\det(J)\neq 0$, the four equilibrium points meet $\det(J)>0$ and $TR(J)<0$, then this point is a stable point.

The stability conditions of four stability points can be obtained by Jacobian matrix, as the table 1

Table 1: The stability conditions of four stability points

N_i	det (J)	Tr (J)	Stability condition
N_1	v_1v_2	v_1+v_2	unstable
N_2	$-v_1v_2(1-\lambda)$	$v_1(1-\lambda)-v_2$	$\lambda>1$
N_3	$-v_1v_2(1-\theta)$	$v_1(1-\theta)-v_2$	$\theta>1$
N_4	$\frac{v_1v_2(1-\lambda)(1-\theta)}{1-\lambda\theta}$	$\frac{v_1(1-\lambda)+v_2(1-\theta)}{\lambda\theta-1}$	$\lambda<1,\theta<1$

It can be seen from the above table that N_1 is not a stable point, N_2 is stable under the condition that the symbiosis coefficient between Meiyijia and 7-11 is greater than 1, N_3 is stable under the condition that the symbiosis coefficient of 7-11 to Meiyijia is greater than 1, and N_4 is stable under the condition that both the symbiosis coefficient of Meiyijia to 7-11 and the symbiosis coefficient of 7-11 to Meiyijia are less than 1. When the symbiosis coefficient of one party to the other party is greater than zero, one party will have a negative influence on the other party. When the symbiosis coefficient of one party to the other party is less than zero, one party has a

positive influence on the other party. The magnitude of the impact is related to the value of the symbiosis coefficient, and the greater its absolute value, the greater the impact.

3.3 Analysis of Symbiosis Mode

According to the stability conditions, due to different symbiotic evolution modes, different values of λ、θ correspond to different stable points, and based on the traditional symbiotic evolution theory, different values of λ、θ correspond to different symbiotic modes [2].

When the symbiosis coefficients of both are 0, 7-11 and Meiyijia are independent of each other and not influenced by each other. When the symbiosis coefficients of both are greater than zero, they have a negative influence on each other, which behaves as a competition mode.

The relationship between the specific symbiosis coefficient and the symbiosis evolution is shown in the following Table 2.

Table 2: The relationship between the symbiotic coefficient and symbiotic evolution.

The relationship between λ and θ	Symbiotic evolution model
$\lambda = 0,\ \theta = 0$	7-11 and Meiyijia are independent of each other and do not affect each other.
$\lambda > 0,\ \theta > 0$	When λ equal to θ, the mode of development between 7-11 and Meiyijia are equal competition; When λ and θ are not equal and if any symbiosis coefficient is greater than 1, the mode of development is vicious competition.
$\lambda * \theta < 0$	There is a parasitic symbiosis mode between 7-11 and Meiyijia.
$\lambda < 0, \theta = 0$ or $\lambda = 0, \theta < 0$	The symbiosis between 7-11 and Meiyijia is a commensalism mode.
$\lambda > 0, \theta = 0$ *or* $\lambda = 0, \theta > 0$	The symbiosis between 7-11 and Meiyijia is an amensalism mode.
$\lambda < 0, \theta < 0$	When λ and θ are not equal, there is an asymmetric mutualism evolution mode between 7-11 and Meiyijia. When λ and θ is equal, it is a symmetric mutualism mode.

3.4 The Symbiosis Coefficient was Evaluated According to Different Symbiosis Modes

According to the stability conditions obtained above, we can know that different competition modes correspond to different stability points. For example, the equal competition mode includes three stability points: N_2, N_3, and N_4, but these three points correspond to different competition intensities. For example, the symbiosis coefficients of the two points (N_2 and N_3) are greater than 1, so 7-11 and Meiyijia are in a state of intense competition. However, the symbiosis coefficients of N_4 are less than 1, indicating that they are in a state of mild competition. The specific values are shown in the following table 3.

Table 3: The specific values

Symbiotic evolution model	The corresponding stable point	Value of the corresponding symbiosis mode
Equal competition	N_2	$\lambda=1.5,\theta=1.5$
	N_3	$\lambda=1.5,\theta=1.5$
	N_4	$\lambda=0.5,\theta=0.5$
Vicious competition	N_2	$\lambda=1.5,\theta=0.5$
	N_3	$\lambda=0.5,\theta=1.5$
Parasitic symbiosis	N_2	$\lambda=1.5,\theta=-0.5$
	N_3	$\lambda=-0.5,\theta=1.5$
	N_4	$\lambda=0.5,\theta=-0.5$
Commensalism	N_4	$\lambda=-0.5,\theta=0$
		$\lambda=0,\theta=-0.5$
Amensalism	N_2	$\lambda=1.5,\theta=0$
	N_3	$\lambda=0,\theta=1.5$
	N_4	$\lambda=0.5,\theta=0$
Asymmetric mutualism	N_4	$\lambda=-0.4,\theta=-0.6$
Symmetric mutualism	N_4	$\lambda=-0.5,\theta=-0.5$

4 Simulated analysis

4.1 The Value Depends on The Actual Situation

The number of convenience stores in Shanghai is 6,430, or one for every 3,769 people, according to the 2020 China Convenience Store Development Report jointly released by the China Chain Store Association (CCFA) and KPMG (Klynveld Peat Marwick Goerdeler). New retail store development in Shanghai is at the forefront of China. Therefore, the data of 7-11 and Meiyijia in Shanghai are selected as their initial scale and assigned according to the actual scale of new retail stores of the two different brands in Shanghai. According to the data for 2020 on the website, the number of 7-11 stores is 201 and Meiyijia stores is 47. X_{10} can be set as 2.01 initially. X_{20} was set as 0.47, the natural growth rate v_1 was set as 0.1 and v_2 as 0.2 for simulation analysis, and the size thresholds M_1 and M_2 were assumed to be 1 and 3 respectively. The final simulation image is obtained.

4.2 Simulation Analysis under Equal Competition Mode

In the mode of equal competition, when the symbiosis coefficient of Meiyijia to 7-11 is 1.5, that of 7-11 to Meiyijia is also 1.5, as shown in Figure 1 (a), it shows that Meiyijia and 7-11has a strong negative impact on each other. The degree of negative impact between the two is equal, and 7-11 will eventually eliminate Meiyijia and reach its own size threshold.

When the symbiosis coefficient of Meiyijia to 7-11 is 0.5, that of 7-11 to Meiyijia is also 0.5, the same as shown in Figure 1 (b). It shows that Meiyijia and 7-11 has a weak negative influence

on each other. Both of them can survive finally, but due to competition, they can't reach their own size threshold.

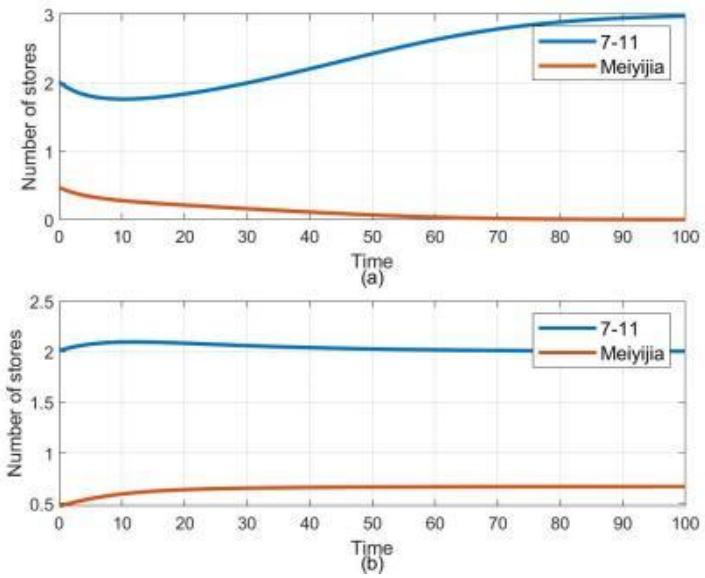

Figure 1: Comparison of Co-evolution curves under different parameters: $(a)\lambda = 1.5, \theta = 1.5$ $(b)\lambda = 0.5, \theta = 0.5$

4.3 Simulation Analysis under Vicious Competition Mode

In the vicious competition mode, when the symbiosis coefficient of Meiyijia to 7-11 is greater than that of 7-11 to Meiyijia, see Figure. 2 (a), it shows that the negative impact of Meiyijia to 7-11 is greater than that of Meiyijia to 7-11. Finally, Meiyijia will reach its size threshold and 7-11 will be eliminated by the market.

When the symbiosis coefficient of 7-11 to Meiyijia is greater than that of Meiyijia to 7-11, as shown in Figure. 2 (b), it indicates that the negative impact of 7-11 to Meiyijia is greater than that of Meiyijia to 7-11. 7-11 will reach its scale threshold and Meiyijia will be eliminated from the market eventually.

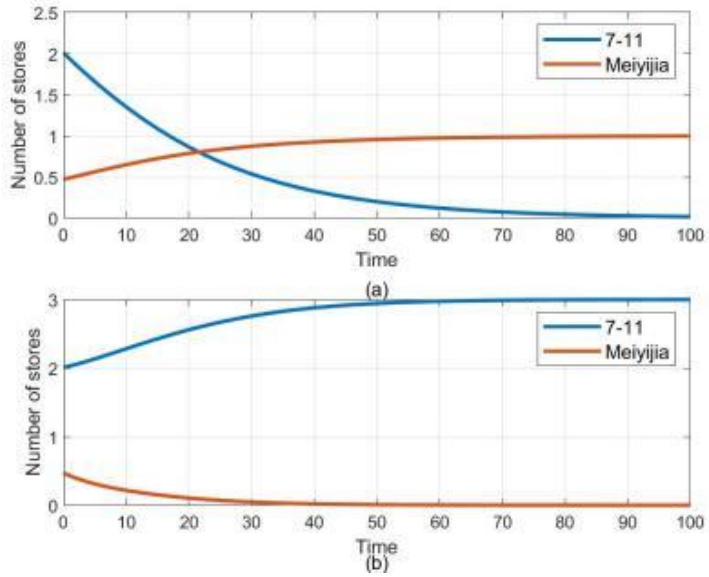

Figure 2: Comparison of Co-evolution curves under different parameters: $(a)\lambda = 1.5, \theta = 0.5$ $(b)\lambda = 0.5, \theta = 1.5$

4.4 Simulation Analysis under Parasitic Symbiosis Mode

In the case of parasitic symbiosis, when the symbiosis coefficient of Meiyijia to 7-11 is 1.5, that of 7-11 to Meiyijia is -0.5, as shown in Figure. 3 (a), it shows that Meiyijia has a strong negative effect on 7-11, but 7-11 has a relatively weak positive effect on Meiyijia. 7-11 will eventually be phased out of the market, while Meiyijia reaches its size threshold.

When the symbiosis coefficient of 7-11 to Meiyijia is 1.5, that of Meiyijia to 7-11 is -0.5, see Figure. 3 (b), it shows that 7-11 has a strong negative impact on Meiyijia, while Meiyijia has a relatively weak positive impact on 7-11. Meiyijia will eventually be phased out of the market, and 7-11 will reach its size threshold.

When the symbiosis coefficient of Meiyijia to 7-11 is 0.5, that of 7-11 to Meiyijia is -0.5, as shown in Figure. 3 (c). It shows that Meiyijia has a negative impact on 7-11, but 7-11 has a positive impact on Meiyijia, but Meiyijia will eventually exceed its size threshold, and 7-11 will not.

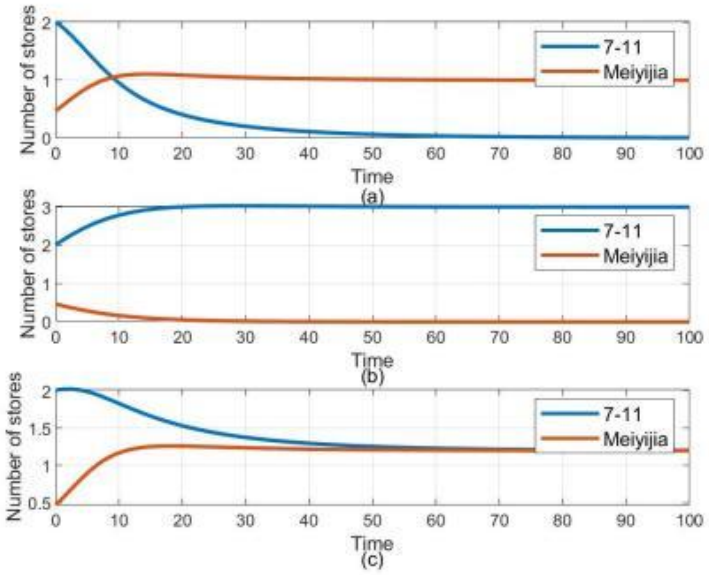

Figure 3: Comparison of Co-evolution curves under different parameters: $(a)\lambda = 1.5, \theta = -0.5$ $(b)\lambda = -0.5, \theta = 1.5$ $(c)\lambda = 0.5, \theta = -0.5$

4.5 Simulation Analysis under Commensalism Mode

In the case of commensalism, when the symbiosis coefficient of Meiyijia to 7-11 is -0.5 and that of 7-11 to Meiyijia is 0, as shown in Figure. 4 (a), it indicates that Meiyijia has a positive impact on 7-11, while Meiyijia has no impact on 7-11. Both of them will survive, Meiyijia will eventually reach its size threshold and 7-11 will eventually exceede its size threshold.

When the symbiosis coefficient of 7-11 to Meiyijia is 0, that of 7-11 to Meiyijia is -0.5, as shown in Figure. 4 (b). It indicates that Meiyijia has a positive influence on 7-11, but 7-11 does not influence Meiyijia. 7-11 eventually develops beyond its size threshold, and Meiyijia can reach its size threshold eventually.

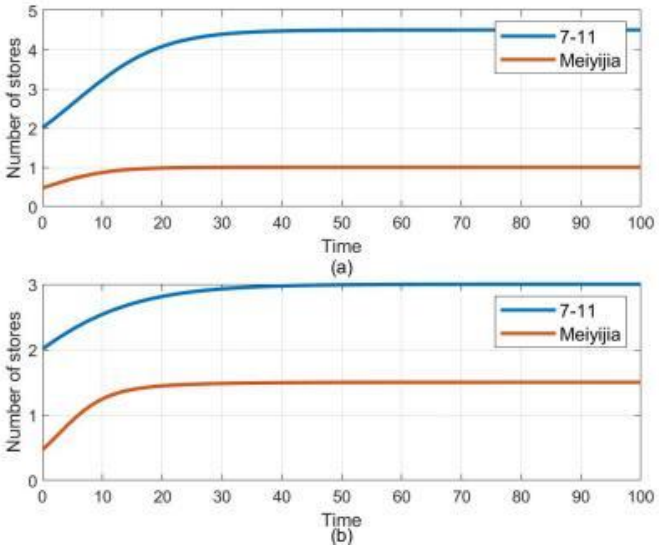

Figure 4: Comparison of Co-evolution curves under different parameters: $(a)\lambda=-0.5,\theta=0$ $(b)\lambda=0,\theta=-0.5$

4.6 Simulation Analysis under Amensalism Mode

In the case of amensalism, when the symbiosis coefficient of Meiyijia to 7-11 is 1.5, that of 7-11 to Meiyijia is 0, see Figure. 5 (a). It shows that Meiyijia has a strong negative effect on 7-11, but 7-11 has no effect on Meiyijia. At this point, 7-11 will gradually be eliminated by Meiyijia, and Meiyijia will gradually reach its size threshold.

When the symbiosis coefficient of Meiyijia to 7-11 is 0, that of 7-11 to Meiyijia is 1.5, as shown in Figure. 5 (b). It shows that Meiyijia has no influence on 7-11, and 7-11 has a strong negative influence on Meiyijia. At this point, 7-11 will gradually reach its size threshold, and Meiyijia will gradually be eliminated.

When the symbiosis coefficient of Meiyijia to 7-11 is 0.5, that of 7-11 to Meiyijia is 0, as shown in Fig.5 (c). It shows that Meiyijia has a weak negative effect on 7-11, and 7-11 has no effect on Meiyijia. At this point, both of them can continue to survive, but Meiyijia can reach its size threshold for development, while 7-11 cannot.

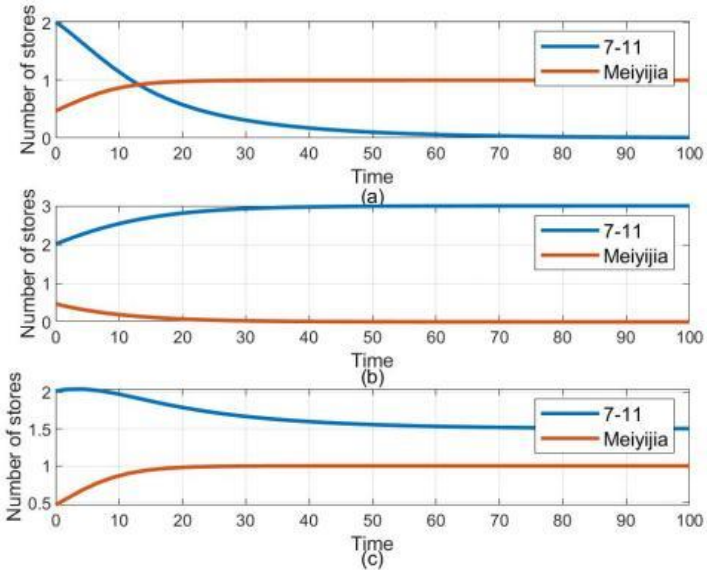

Figure 5: Comparison of Co-evolution curves under different parameters: $(a)\lambda = 1.5, \theta = 0$ $(b)\lambda = 0, \theta = 1.5$ $(c)\lambda = 0.5, \theta = 0$

4.7 Simulation Analysis under Asymmetric Mutualism Mode

In the case of asymmetric mutualism, the symbiosis coefficient of Meiyijia to 7-11 is -0.4, and that of 7-11 to Meiyijia is 0.6, as shown in Figure 6. It shows that Meiyijia has a positive impact on 7-11 and 7-11 has a positive impact on Meiyijia. The positive impact of 7-11 on Meiyijia is greater than that of Meiyijia on 7-11. At this point, 7-11 and Meiyijia can exceed its size threshold.

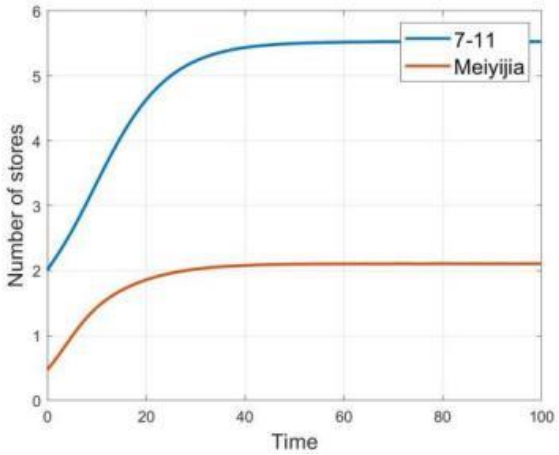

Figure 6: Comparison of Co-evolution curves under different parameters: $\lambda = -0.4, \theta = -0.6$

4.8 Simulation Analysis under Symmetric Mutualism Mode

In the case of symmetric mutualism, the symbiosis coefficient of Meiyijia to 7-11 is -0.5, and that of 7-11 to Meiyijia is also -0.5, as shown in Figure 7. It shows that Meiyijia has a positive influence on 7-11, and 7-11 also has a positive influence on Meiyijia, and the two have the same influence on each other. At this point, both 7-11 and Meiyijia can grow beyond their size thresholds.

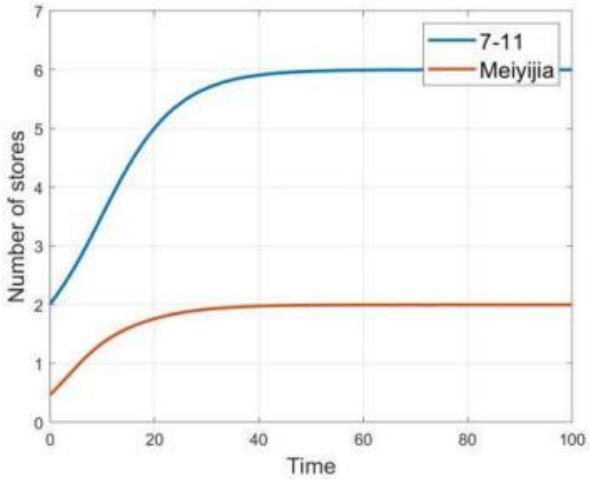

Figure 7: Comparison of Co-evolution curves under different parameters: $\lambda = -0.5, \theta = -0.5$

5 Conclusions

As a local emerging brand in China, Meiyijia has only started to enter Shanghai in the last two years. However, as a first-tier city in China, the market of new retail stores in Shanghai tends to be saturated, and its development space is limited. Therefore, Meiyijia is relatively weak in competition. If it adopts a more intense head-on competition strategy against 7-11, 7-11 will adopt corresponding competition measures. As a result, for an emerging local new retail chain store brand like Meiyijia, it is more likely to develop in Shanghai for a long time to choose the mode of partial symbiosis, symmetric symbiosis or asymmetric symbiosis in the process of entering Shanghai.

To avoid vicious competition, relevant departments should guide 7-11 and Meiyijia to cooperate. At the same time, they could induce local emerging convenience store brands such as Meiyijia to develop into the blank area of the market, so as to properly adjust the number of Meiyijia stores. In this way, both of them can exceed their own scale thresholds, develop in Shanghai for a longer period of time, and provide better and comprehensive services for Shanghai residents.

Meiyijia should properly provide its special services in the process of development and operation, rather than blindly imitating Japanese peers. If only has blind imitation, it will form

a direct competitive relationship with mature Japanese brand convenience stores. Due to its small initial scale and weak strength in Shanghai, it is not conducive to the development of Meiyijia.

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