RESEARCH ON SYMBIOTIC PATTERN AND EVOLUTION OF ONLINE RETAIL, THIRD-PARTY PAYMENT AND EXPRESS DELIVERY INDUSTRY

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ABSTRACT. *With the progress of information technology, the third-party payment and express delivery have formed a symbiotic development trend with online retail as the core. Based on the Logistic growth model, this paper analyzes the symbiotic relationship and evolution trend of the third-party payment, online retail and express industry. By comparing the market size data of the three industries from 2007 to 2021, the symbiotic degree, symbiotic relationship, symbiotic mode and symbiotic growth rate among the three industries were analyzed, and the population density of the three industries was estimated. The maximum annual environmental capacity of the symbiotic population is calculated and compared with the actual market size. The results show that the positive symbiosis pattern of the third-party payment, online retail and express delivery industries is gradually stable, and the development momentum of the three industries is good.*
Keywords: Online retail, Third-party payment, Express delivery, Symbiotic pattern

1. **Introduction.** With the rapid development of network economy, the scale of online retail market keeps increasing. According to the latest data of the National Bureau of Statistics, in 2021, the online retail volume of physical goods is 10,804.2 billion yuan. According to the Statistics of the State Post Bureau, the income of the national express service will reach 1,033.2 billion yuan. The transaction scale of third-party payment will reach 288 trillion yuan. With the growth of online retail transaction business, the third-party payment and express delivery have formed a symbiotic combination. Therefore, it is significant to study the symbiotic development of online retail, third-party payment and express delivery.

Liu [1] studied the advantages and risks of third-party payment in the process of online retail platform payment. Zheng [2] studied the symbiotic relationship between online retail platform and express delivery enterprise, and the optimal symbiotic model of symbiosis. Zhang [3] measured the symbiotic relationship among China's online retail platform, third-party payment and express delivery industry by using Logistic model. Shi [4] studied the symbiotic evolution relationship within the online retail platform system by using the Logistic model in segments.

A comprehensive literature review shows that many scholars have studied the symbiotic relationship between online retail and third-party payment or express delivery industry, but few scholars have conducted a comprehensive analysis of the symbiotic relationship between these three industries. And the data is only before 2017. Therefore, this paper updates the data from 2017 to 2021, based on a symbiotic perspective. Through the symbiosis degree, symbiosis coefficient and symbiosis density, the symbiosis mode of

online retail, third-party payment and express industry was distinguished, and the Logistic growth model was used to calculate the natural growth rate of the three industries. Combined with the existing market size, the maximum environmental capacity curve of the annual market was estimated, and the evolution and development law of these three industries were analyzed.

2. Theoretical Basis of Symbiosis.

2.1. **Symbiosis theory.** Symbiosis is an important biological concept proposed by the German biologist Debele [5]. It means that "different organisms live together in a close connection". Yuan [6] introduced symbiosis theory into the field of economics. The core of symbiosis is to live together to achieve mutual win-win. Symbiosis refers to the relationship formed by symbiosis unit in the external symbiosis environment according to a certain symbiosis pattern.

1) Symbiotic unit refers to the basic energy generation and exchange unit in symbiotic action. The symbiotic units in this paper mainly include online retail platform, third-party payment industry and express industry.

2) Symbiosis pattern refers to the way in which symbiosis units interact with each other. The discriminant indexes include symbiosis degree, symbiosis coefficient and symbiosis density. In natural systems, symbiosis can be divided into parasitism, favoritism, asymmetric mutualism and symmetric mutualism.

3) Symbiotic environment is the external factor affecting the symbiotic pattern between symbiotic units, including economic development environment, social and cultural environment, policy and legal environment, science and technology environment, etc.

2.2. **Logistic model.** In biology, symbiosis theory generally uses Logistic model to describe the law of population growth [7]. In 1838, Belgian mathematician Verhaas came up with the Logistic equation: $\frac{dN(t)}{dt} = RN\left(1 - \frac{N}{K}\right)$, the constant R is the internal growth rate of the population, K reflects the degree of resource abundance, and N represents the current resource status [8]. The Logistic equation can also be understood as follows: all available resources of the population are regarded as one unit, and these resources can guarantee the survival of K individuals of the population, so each individual consumes $\frac{1}{K}$ of the average of available resources, that is, the Logistic equation shows that the growth rate of population size is proportional to the resources [9]. Therefore, this paper adopts the Logistic equation as the model of the study.

3. Symbiosis Pattern Analysis.

3.1. Symbiosis pattern discriminant index.

1) Symbiosis degree: It reflects the degree of interaction between the energy of two mass parameters. Assuming that there are symbiotic units a and b, and they have qualitative parameters N_a and N_b respectively, then you can get symbiosis degree: $\delta_{ab} = \frac{N_b dN_a}{N_a dN_b}$.

TABLE 1. Symbiosis degree indicators meaning

	$\delta_{ab} > 0$	$\delta_{ab} = 0$	$\delta_{ab} < 0$
$\delta_{ba} > 0$	Positive symbiosis	Dominance symbiosis	Parasitic
$\delta_{ba} = 0$	Dominance symbiosis	Not influence	Dominance symbiosis
$\delta_{ba} < 0$	Parasitic	Dominance symbiosis	Reverse symbiosis

2) Symbiosis coefficient: A measure of the degree of interaction between symbiotic units. $\theta_{ab} = \frac{|\delta_{ab}|}{|\delta_{ab}||\delta_{ba}|}$; $\theta_{ba} = \frac{|\delta_{ba}|}{|\delta_{ab}||\delta_{ba}|}$; $\theta_{ab} + \theta_{ba} = 1$.

3) Symbiotic density: In a symbiotic relationship, the number of symbiotic units of the same kind reflects the density of symbiotic units. N represents the number of symbiotic

TABLE 2. The meaning of symbiosis coefficient

θ_{ab}	Meaning
$\theta_{ab} = 0$	a has no effect on b
$0 < \theta_{ab} < 0.5$	The influence of a on b is less than that of b on a
$\theta_{ab} = 0.5$	The influence of a on b is equal to that of b on a
$0.5 < \theta_{ab} < 1$	The influence of a on b is greater than that of b on a
$\theta_{ab} = 1$	a has a significant effect on b, and b has no effect on a

units of the same kind, V represents the symbiotic space, and ρ represents the symbiotic density, so $\rho = \frac{N_a}{V}$.

3.2. **The empirical analysis.** The online retail in this paper refers to the direct sale of goods and services to the end consumers through the media of the Internet, which is a commercial transaction. Third-party payment refers to an independent institution with a certain reputation. By signing contracts with major banks, it connects with banks to facilitate the payment mode of both sides of the transaction.

Data were selected from China Statistical Yearbook from 2007 to 2021 as the reference quality and population density of the symbiotic unit, including online retail transaction scale (N_1), express transaction scale (N_2) and third-party mobile payment transaction scale (N_3). The unit of market scale (N) is hundreds of millions of yuan. δ is degree of symbiosis; θ stands for symbiosis coefficient.

1) The symbiotic pattern of online retail platform and express delivery industry

It can be seen from Table 3 and Figure 1 that from 2007 to 2011, online retail had a great impact on the express industry. The express industry relied on online retail platforms, and the two sides were in an asymmetric mutualism mode with unequal influence. From 2012 to 2021, $\delta_{12} \approx \delta_{21} \approx 1$, $\theta_{12} \approx \theta_{21} \approx 0.5$ indicates that the development of online retail and express delivery in China is in a positive symmetry state, that is, both have a positive and equal effect on each other, which is a symbiotic mode of symmetry and mutual benefit.

2) The symbiotic pattern of online retail platform and third-party payment

It can be seen from Table 3 and Figure 1 that from 2007 to 2011, third-party payment had a great impact on online retail, and online retail had almost no impact on third-party

TABLE 3. Degree of symbiosis

| Year	N_1	N_2	N_3	δ_{12}	δ_{21}	δ_{13}	δ_{31}
2007	560	343	46	8.4102	0.1176	0.0035	277.1026
2008	1282	408	210	4.3699	0.2262	0.0069	138.9566
2009	2630	479	390	2.5008	0.3953	0.0063	151.7467
2010	5141	575	586	1.5358	0.6437	0.0048	199.6919
2011	8019	758	800	1.2979	0.7617	0.0042	228.1606
2012	13250	1055	1511	1.0933	0.9043	0.0048	199.6006
2013	18851	1442	12168	1.0503	0.9412	0.0271	35.2635
2014	28211	2045	59892	0.9954	0.9932	0.0892	10.7216
2015	38285	2770	121859	0.9935	0.9951	0.1337	7.1512
2016	51556	3974	588004	1.0584	0.9341	0.4790	1.9958
2017	71751	4957	1203000	0.9486	1.0422	0.7042	1.3576
2018	90065	6038	1905000	0.9205	1.0740	0.8884	1.0761
2019	106324	7498	2261000	0.9683	1.0210	0.8931	1.0704
2020	117601	8795	2492000	1.0269	0.9627	0.8900	1.0742
2021	130884	10332	2881000	1.0839	0.9121	0.9245	1.0341
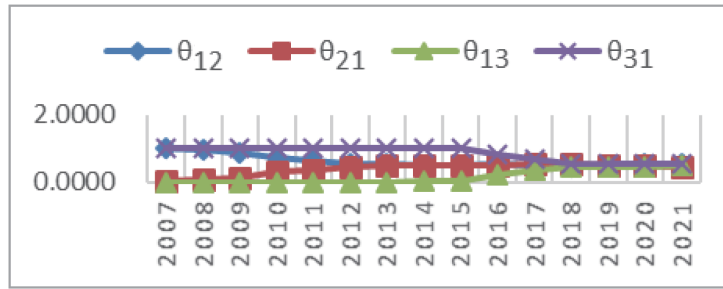
FIGURE 1. Symbiosis coefficient

payment, which was in a positive symbiosis mode. From 2012 to 2016, both have a positive effect on each other, but the effect of the two parties is not equal, which is in the stage of asymmetric mutualism. From 2017 to 2021, $\delta_{13} \approx \delta_{31} \approx 1$, $\theta_{13} \approx \theta_{31} \approx 0.5$ indicates that the development of online retail platform and third-party payment in China is in a positive symmetry state, which is a symbiotic pattern of symmetry and mutual benefit.

4. Logistic Model Analysis.

4.1. Model building.

4.1.1. *Symbiotic model stability model.* Using Logistic equation to study symbiosis problem is mainly to analyze the symbiosis model stability and its own evolution law of symbiotic unit. In this paper, the Logistic equation is taken as the basic growth model, and MATLAB software is used to deduce the evolution law of online retail, third-party payment and express delivery.

TABLE 4. Symbiotic formula letter meaning

	Population density	Natural growth rate	Maximum environmental capacity	Initial population density
Online retail	N_1	R_1	K_{m1}	N_{10}
Express delivery	N_2	R_2	K_{m2}	N_{20}
Third-party payment	N_3	R_3	K_{m3}	N_{30}

When the above three industries develop independently, the evolution equation of the symbiotic population is as follows:

$$\frac{dN_1(t)}{dt} = R_1 \left[1 - \frac{N_1(t)}{K_{m1}} \right] N_1(t) \quad N_1(t_0) = N_{10} \tag{1}$$

$$\frac{dN_2(t)}{dt} = R_2 \left[1 - \frac{N_2(t)}{K_{m2}} \right] N_2(t) \quad N_2(t_0) = N_{20} \tag{2}$$

$$\frac{dN_3(t)}{dt} = R_3 \left[1 - \frac{N_3(t)}{K_{m3}} \right] N_3(t) \quad N_3(t_0) = N_{30} \tag{3}$$

In the above formula, $\frac{N_1(t)}{K_{m1}}$, $\frac{N_2(t)}{K_{m2}}$, $\frac{N_3(t)}{K_{m3}}$ are respectively the proportion of the output capacity of online retail platform, express industry and third-party payment to their own maximum output. It is affected not only by the external environment, but also by the interaction between each other. Therefore, after considering the interaction, interaction and symbiotic evolution equation of express delivery and online retail, third-party payment and online retail can be obtained:

$$
\begin{cases}
\dfrac{dN_1(t)}{dt} = R_1 \left[1 - \dfrac{N_1(t)}{K_{m1}} + \delta_{12} \cdot N_2(t) \right] N_1(t) \\[4mm]
\dfrac{dN_2(t)}{dt} = R_2 \left[1 - \dfrac{N_2(t)}{K_{m2}} + \delta_{21} \cdot N_1(t) \right] N_2(t)
\end{cases} \tag{4}
$$

$$
\begin{cases}
\dfrac{dN_1(t)}{dt} = R_1 \left[1 - \dfrac{N_1(t)}{K_{m1}} + \delta_{13} \cdot N_3(t) \right] N_1(t) \\[4mm]
\dfrac{dN_3(t)}{dt} = R_3 \left[1 - \dfrac{N_3(t)}{K_{m3}} + \delta_{31} \cdot N_1(t) \right] N_3(t)
\end{cases} \tag{5}
$$

4.1.2. *Analysis of symbiotic unit evolution.*

1) Population density growth model

When the symbiotic relationship between symbiotic units is not taken into account, the initial environmental capacities of online retail and express are set as K_{L10} and K_{L20} respectively, and are the symbiotic impact factor values of express on online retail platform and online platform on express respectively, where $\alpha_{12} > 0$, $\alpha_{21} > 0$, $G_1(\Delta E)$ and $G_2(\Delta E)$ are the changes of symbiotic resources. When $t = 0$, $\Delta E = 0$, the effect coefficients of resource changes on the population density of online retail markets and third-party payment markets are β_1 and β_2. Therefore, the symbiotic environment capacities of online retail market and express market under the restriction of external environment are respectively:

$$
\begin{cases}
K_{L1}(t) = K_{L10} + \alpha_{12} F(N_2(t)) + \beta_1 G_1(\Delta E) \\
K_{L2}(t) = K_{L20} + \alpha_{21} F(N_1(t)) + \beta_2 G_2(\Delta E)
\end{cases} \tag{6}
$$

Therefore, the population density growth of online retail and express market, online retail and third-party payment markets conforms to the Logistic equation:

$$
\begin{cases}
\dfrac{dN_1}{d\Delta t} = R_1 N_1 \left[1 - \dfrac{N_1}{K_{L1}(t_T + 1)} \right] \\[4mm]
\dfrac{dN_2}{d\Delta t} = R_2 N_2 \left[1 - \dfrac{N_2}{K_{L2}(t_T + 1)} \right]
\end{cases} \tag{7}
$$

$$
\begin{cases}
\dfrac{dN_1}{d\Delta t} = R_1 N_1 \left[1 - \dfrac{N_1}{K_{L1}(t_T + 1)} \right] \\[4mm]
\dfrac{dN_3}{d\Delta t} = R_3 N_3 \left[1 - \dfrac{N_3}{K_{L3}(t_T + 1)} \right]
\end{cases} \tag{8}
$$

2) Environmental capacity estimation model

The first step to estimate the symbiotic growth model is to estimate the environmental capacity of the two populations. On the growth curve of the population density of the two populations, it is assumed that the increment of the population density of the two populations in the time period $[t_T, t_{T+1}]$, assuming that $\Delta t_T = t_{T+1} - t_T = 1$. The population density change rate of the online retail is $\frac{\Delta N(t)}{\Delta t_T} = \Delta N_1(t_T)$, $\Delta N_1(t_T) \cong R_1 * \overline{N_1(t_T)} * \left[1 - \frac{N_1(t_T)}{K_{L1}(t_{T+1})} \right]$.

The next step is to get the iterative formula: $K_{L1}(t_{T+1}) = \frac{R_1 * \overline{N_1(t_T)}}{R_1 - \frac{\Delta N_1(t_T)}{N_1(t_T)}} = \mu(R_1)$. If R_1 is given any initial value $\widehat{R_1}$, it can be estimated by the initial value $\widehat{K_{L1}(t_{T+1})}$, and then, the estimated value $\widehat{N_1(t_T)}$ can be calculated and found. The sum of error squares is corrected to zero: $S_i^2 = \sum_{i=0}^{n} \left(\frac{N_{if}(t_{i+1}) - \widehat{N_{iS}(t_{i+1})}}{N_{if}(t_{i+1})} \right)^2$, S_i^2 is a function of $\widehat{R_1}$; therefore, the above formula can be obtained of $\widehat{R_1}$ by programming with MATLAB software; based

on this, the maximum population density of online retail market can be calculated every year.

4.2. **The empirical analysis.**

4.2.1. *Stability analysis of symbiosis pattern.*
1) Stability of the symbiotic pattern between express delivery industry and online retail.

To achieve a stable state, the symbiosis pattern between express delivery industry and online retail platform needs to satisfy the differential equation (4) equal to 0. After solving the differential equation, $Z_1(K_{m1}, 0)$, $Z_2(0, K_{m2})$, $Z_3(0, 0)$, $Z4\left[\frac{K_{m1}(1+\delta_{21})}{1-\delta_{12}\delta_{21}}, \frac{K_{m2}(1+\delta_{12})}{1-\delta_{12}\delta_{21}}\right]$ can be obtained. For these points, $Z_1(K_{m1}, 0)$, $Z_2(0, K_{m2})$ and $Z_3(0, 0)$ indicate that there is no output on one side, and symbiosis between enterprises is even more impossible. The symbiotic relationship has a positive impact on both industries, so the stability point is in the first quadrant: $\frac{K_{m1}(1+\delta_{21})}{1-\delta_{12}\delta_{21}} > 0$, $\frac{K_{m2}(1+\delta_{12})}{1-\delta_{12}\delta_{21}} > 0$, so the stability condition is $\delta_{12}\delta_{21} < 1$. It can be seen from Table 3 that the symbiotic pattern of express delivery industry and online retail is in a stable state during the 15 years.

2) Stability of the symbiotic pattern between third-party payment and online retail.

When the symbiosis pattern of third-party payment and online retail platform reaches a stable state, differential equation (4) should be equal to 0. Similarly, the stability condition is $\delta_{13}\delta_{31} < 1$. It can be seen from Table 3 that the symbiotic patterns of third-party payment and online retail are in a stable state during the 15 years.

4.2.2. *Analysis of symbiotic unit evolution.*
1) Analysis of population density growth rate

Online retail platform: After calculation, the natural growth rate of the online retail platform is 1.15, the value between the express industry growth rate with the third party payment, and online retail remnant resources is somewhere in the middle, and development potential is also located in the middle; After explosive growth, the online retail market has reached a certain scale of development. In order to seek better development, it is necessary to understand the needs of consumers, rely on big data as support, and develop differentiated platforms.

Express delivery: After calculation, the natural growth rate of the express delivery market is 0.45, which is relatively the smallest, indicating that there are relatively few remaining resources and relatively small development potential, on the basis of large-scale users now, continue to explore the user has the certain difficulty. In the future, only continuous improvement of service quality, application of digital technology, improvement of the overall level of the industry, reasonable layout of outlets can maintain the competitive advantage of the express industry.

Third-party payment industry: After calculation, the natural growth rate of the third-party payment market is 1.75, with the fastest growth rate indicating that the more remaining resources there are, the greater the development potential. In 2016, Alipay returned to payment from social networking, which not only firmly consolidated its leading position, but also injected new vitality into the third-party payment market. Therefore, third-party payment platforms should actively innovate and constantly explore new fields to achieve better development.

2) Capacity analysis of symbiotic environment

Online retail platform: It can be seen from Figure 2 that the actual population density and environmental capacity of the online retail market increased gently from 2007 to 2021, the distance between the two increased, the difference increased year by year, indicating that the development of the market needs to be improved. Facing the pressure of competition, have to seek new fields and break through the existing limitations.
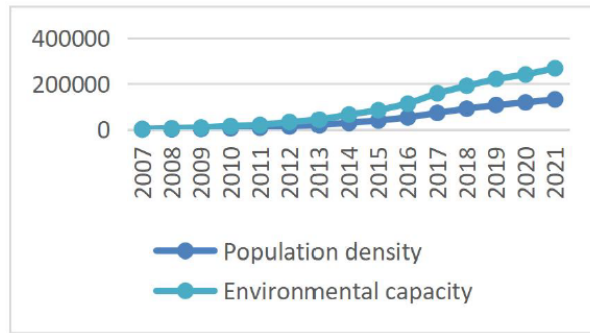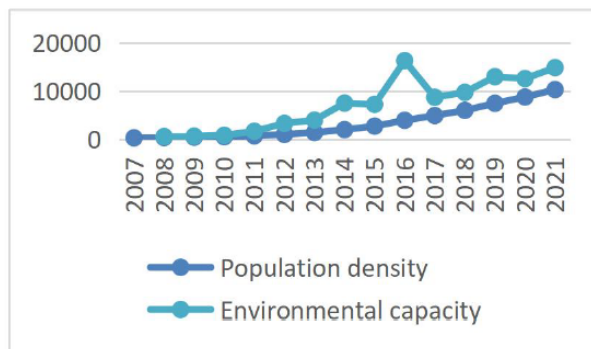
FIGURE 2. Evolution curve of online retail

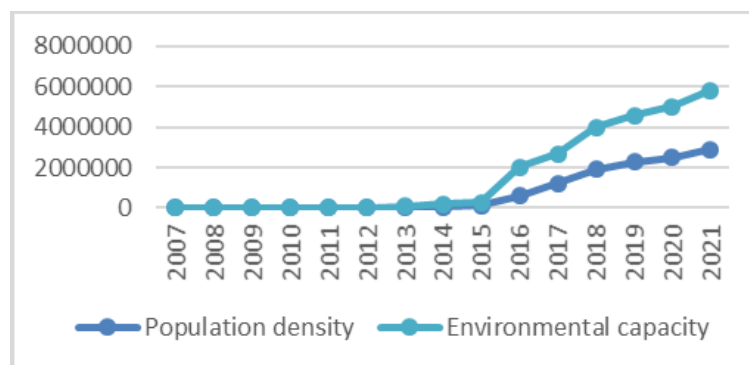FIGURE 3. Evolution curve of express industry

FIGURE 4. Evolution curve of third-party payment

Express delivery: Figure 3 illustrates the population density of the express industry and the environmental capacity in addition to the individual years, the trend is almost consistent, but the express industry relies heavily on online retail platform, service level is not high, lack of creativity, entire industries in the future the express industry in addition to enhancing their competitiveness, also need to make good use of the external environment factors.

Third-party payment industry: It can be seen from Figure 4 that the third-party payment market stretched in 2016, and its differential growth rate also rose sharply, indicating that the third-party payment market can maximize the enthusiasm of development under the effect of external environment, make good use of the resources it has, and realize the optimal allocation of resources. However, Alipay and Tenpay occupy more than 90% of the market share, so as to improve the market share of small and medium-sized enterprises in the market, realize diversified development, improve the competitiveness of small and medium-sized enterprises, and reduce market security risks.

5. **Conclusions and Outlook.** Based on symbiosis theory, this paper draws the following conclusions through data research and analysis from 2007 to 2021.

1) The symbiosis pattern tends to be symmetrical mutualism.

The calculation results of symbiosis degree and symbiosis coefficient show that online retail and express delivery industry, online retail and third-party payment industry are in a favorable symbiosis pattern from 2007 to 2011. From 2012 to 2016, online retail and express delivery industry, online retail and third-party payment industry were in asymmetric mutual benefit pattern. From 2017 to 2021, online retail and express delivery industry, online retail and third-party payment industry have gradually been in a positive symbiotic pattern of mutual benefit.

2) The symbiotic pattern is in a stable stage.

In this paper, the logistic equation was used to study the stability of the symbiosis pattern. Online retail, third-party payment industry and express industry respectively constituted two groups of symbiosis pattern combinations, and the calculation showed that the two groups of symbiosis pattern has been in a stable state.

3) The three industries have a good momentum of development.

Through the Logistic symbiosis pattern, the symbiotic natural growth rate can be obtained in the process of population density estimation, from which the maximum population density can be obtained, and the evolution of environmental capacity can be obtained by comparing it with the actual population density. The remaining resources of online retail market are in the middle, and the development potential needs to be released. The more resources left in the third-party payment market, the greater the development potential. Express industry market remaining resources are relatively small, and the development potential is relatively small.

The ideal symbiosis pattern is that symbiosis units such as online retail platform, third-party payment and express industry cooperate together to better balance the symbiosis degree and improve the stability of symbiosis. Therefore, not only the cooperation between online retail platform enterprises and third-party payment platform enterprises, but also the cooperation between online retail platform enterprises and express delivery enterprises is needed. This paper only uses the overall data of the industry to analyze the symbiosis relationship between online retail, logistics and third-party payment. Since it is difficult to collect the data of each province, it is impossible to compile the table of symbiosis degree and symbiosis coefficient among the three provinces, and the symbiosis theory has other dimensions, which can be further studied in these aspects in the future.

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