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Assessment of Enterprise Life Cycle Based on Two-Stage Logistic Model: Exemplified by China's Automobile Manufacturing Enterprises

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Abstract: Enterprises in socio-economic ecosystems, like organisms in natural ecosystems, have life cycles. Since the enterprise life cycle theory was proposed, how to measure the enterprise life cycle has been a hot research topic. In order to assess the life cycle of an enterprise, a two-stage logistic model was proposed in this research, based on ecological theory and a population dynamics model. The first-stage logistic model measures the internal inhibition coefficient, intrinsic growth rate, and theoretical upper limit of enterprise development scale. The second-stage logistic model deals with the theoretical upper limit of enterprise development scale in the declining period, and measures the intrinsic growth rate, internal inhibition coefficient, and the theoretical upper limit of enterprise development scale in the declining period. In this study, an empirical analysis is conducted with Chinese automobile enterprises, which shows that an enterprise should withdraw from the market by insolvency liquidation or restructuring when both the intrinsic growth rate and internal inhibition coefficient are less than zero. Finally, this paper proposes the evaluation matrix of intrinsic growth and market potential. This matrix can intuitively give the evaluation method of the enterprise life cycle.

Keywords: two-stage logistic model; life cycle; recession period; automobile manufacturing enterprise


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1. Introduction

Like any living creatures, enterprises also have a life cycle, during which enterprises generally go through different stages of growth, expansion, and decline, with different goals and different risks in variable phases. The enterprise life cycle theory focuses on the evolution of the enterprise. Therefore, how to make a reasonable division of the enterprise life cycle into different stages is the focus of scientific research on enterprise life cycle issues. In the economic society, researchers can correctly judge and grasp the variable phases of the enterprise development only in line with the reasonable division of the different stages of the enterprise life cycle so as to set the corresponding reasonable strategic goals and take effective implementation measures to ensure a healthy, stable, and sustainable development of the enterprise. In view of this, it is not only of theoretical significance, but also of practical significance to study the scientific and reasonable division of the enterprise life cycle.

1.1. Enterprise Life Cycle

Haire, one of the first scholars to introduce the concept of the corporate life cycle, pointed out in his *Modern Organization Theory* in 1959 that the entire life cycle of an enterprise has great similarity to the growth curve of a biological organism, and therefore the "life cycle" perspective of biology can be used to view the development of an enterprise [1]. He further pointed out that stagnation and even extinction can occur in the process of enterprise development, and the main reason for these phenomena is the inadequacy of the

enterprise's management, which means that the limitations of the enterprise's management may cause the limit of its own development.

Greiner [2] further elaborated on the unique characteristics of the "enterprise life cycle" in his article *Evolution and Revolution as Organizations Grow*, pointing out that the enterprise life cycle has three special features compared to the life cycle of living things. First, the enterprise life cycle is difficult to predict, and its progress time of different enterprises varies with some enterprises experiencing a life cycle of only 20–30 years, while others may experience centuries. Secondly, during its life cycle, an enterprise may experience a stagnation phase, where the trend of the enterprise neither shows a significant increase nor a significant decrease, which is not present in the biological life cycle. Third, the final death process in the life cycle can be avoided, such as via regeneration through technological innovation or entering a new development field, thus entering a brand new life cycle stage.

Adizes, one of the prominent early scholars in the study, conducted one of the most systematic and comprehensive studies concerning the enterprise life cycle. He first defined the concept in detail and described the typical characteristics of each stage, thus engaging in refining and further study of the enterprise life cycle theory [3]. After that, Penrose and Penrose [4] pointed out that enterprises go through three processes of occurrence, development, and death. More and more scholars have conducted more in-depth and systematic research on life cycles and formed a more complete life cycle theory, which has become an important theory in modern business management theory. There are obvious differences in its resources and capabilities, organizational structure, and decision-making procedures, as well as strategic objectives and resource requirements, which provide a specific context for the business management behavior of the enterprise executives.

Habib and Hasan [5] suggested that the resource base of an enterprise and the efficiency of its management are important drivers of the turnover that occurs in the enterprise's life cycle. Therefore, understanding the nature of resources that undergo turnover in its life cycle can help the enterprise to achieve and maintain optimal growth by utilizing valuable resources in an optimal manner to outperform competitors. Scholars have developed complex life cycle assessment systems based on resource endowment theory [6–9].

To sum up, the enterprise life cycle theory fully draws on the life cycle theory in biology, which is based on the similarities between the enterprise development cycle and the life cycle of biology. Scholars did not copy the life cycle theory and methods of biology. On the one hand, enterprise is not a simple organism after all. On the other hand, it also leads to the underutilization of ecological and biological methods in enterprise life cycle research. In recent years, the expansion of ecological theories and methods has helped the development of research. Theory is more perfect, systematic, and scientific. This research is also trying to expand the theory and methods of enterprise life cycle research.

1.2. Stages of Enterprise Life Cycle

There have been criteria for dividing the phases of an enterprise's life. Some scholars have divided the life cycle into three stages, such as Downs [10], Lippitt and Schmidt [11], and Smith et al. [12]; some, such as Steinmetz [13] and Quinn and Cameron [14], have divided it into four stages; and some have divided it into five stages, such as Galbraith [15] and Miller and Friesen [16]. In addition, Flamhoitz [17] and Adizes [3] proposed that the business life cycle can be divided into seven and ten stages, respectively. It can be seen that from the 1960s to the present, the indicators used to divide the stages of the enterprise life cycle have varied widely, with the lowest number of indicators used being one, namely enterprise size and time, and the highest number being ten, as in the division method of Adizes [3].

Since Chandler's [18] seminal work on the organizational life cycle, research on the vertical developmental history of enterprises and their characteristics has begun to receive widespread attention from organizational scholars. The firm life cycle (FLC) theory suggests that firms, like organic species in nature, go through a series of developmental processes

from birth to growth, maturity, and decline. Enterprises have different resources and capabilities, face different goals and challenges, and exhibit different characteristics in terms of organizational decisions and corporate performance. Therefore, enterprises set up specific situations that differentiate the decision-making behavior of managers and require them to choose problem-solving approaches and strategies in a flexible manner.

Enterprises at different stages of development differ significantly in terms of corporate resources, organizational structure, decision-making methods, strategic goals, and resource needs [19]. Miller and Friesen proposed a five-stage model of the enterprise life cycle and described the different characteristics of enterprises at each stage. The five-stage life cycle includes: birth phase, growth phase, maturity phase, revival phase, and decline phase [20].

Enterprise life cycle theory regards an enterprise as an organic living organism. An enterprise also has a process of birth to growth to extinction. Based on the general rules of enterprise development and growth process, the standard enterprise life cycle usually has different cycle stages such as introduction, growth, maturity, and decline. The real situation is much more delicate, due to the uniqueness of each enterprise and the uncertainty of the market; not every enterprise goes through a complete four or five stages, and the order of different stages may be reversed and repeated.

The purpose of studying enterprise life cycle theory is to find out the characteristics of organizational structure, management mode, development strategy, and production and operation risks that are compatible with the life cycle stages, so as to guide managers to adjust and formulate enterprise management development and achieve sustainable growth with the revelation that enterprises in different life cycle stages have different characteristics and problems. In recent years, the research on enterprise life cycle has gained new development [21–25]. The division of enterprise life cycle phases and their division standards can be summarized in the following table.

As shown in Table 1, three and four phases are the most common. Based on the viewpoint of industrial ecology, the enterprise life cycle is inextricably linked with the sustainable development of enterprises [26–30]. Enterprise life cycle and product life cycle are both related and different concepts. To some extent, the life cycle of an enterprise can be regarded as the sum of all product life cycles of the enterprise [27–30].

Table 1. Division of enterprise life cycle stages and its division criteria.

Life Cycle Phase	Phase Division Criteria	References
Three phases: inception, high growth, maturity	The growth speed, size, and age of the organization; financial performance; innovation investment	[10–12,21–23]
Four phases: birth, growth, maturity, and decline	Management system and organizational structure; subjective scoring; number of employees	[13,14,24,25]
Five phases: nascent stage, growth stage, mature stage, recession stage, and recovery stage	Organizational growth rate	[15,16,20]
Seven phases: new venture, expansion, professionalization, consolidation, diversification, integration, decline.	Market niche, product, resources required, operational systems	[17]
Three stages (10 phases): gestation stage (gestation period, infant period, and toddler period), growth stage (puberty, heyday, and stable period), aging stage (aristocratic period, early bureaucratic period, bureaucratic period, and death period)	Achieve enterprise goals and administration, innovation spirit, integration	[3]

1.3. Assessment of Enterprise Life Cycle

For the stage division, indicators often used are firm age, asset growth rate, and sales growth rate [31,32], as well as capital expenditure rate, sales growth rate, firm age, and dividend payout rate [33]. In contrast to the use of individual indicators, some literature has argued that the combination of cash flows from financing, investing, and

operating activities of an enterprise can better reflect the life cycle of an enterprise [34–39]. Based on the summary of previous life cycle divisions and combining the approach of Gort and Klepper to divide the enterprise's life cycle into five stages [40]—introduction, growth, maturity, turbulence, and decline—Dickinson [41] portrayed the cash flows of financing, investing, and operating activities in different stages of the enterprise's cash flow statement characteristics of the net amount and investigated the future profitability of firms at different stages.

Among the many measures of firm life cycle, firm (IPO or establishment) age is an intuitive measure [42,43] and is supported by evidence of regular changes in enterprise growth rate and growth. Evans, using a sample of 100 U.S. manufacturing firms and 20,000 U.S. small and medium enterprises, respectively, empirically found that the growth rate of employees decreases as the age of the enterprise increases [44,45]. Farinas and Moreno [46] found that the growth rate of size (employee growth rate) decreases with the age of the enterprise. Yasuda [47], using a sample of nearly 14,000 Japanese manufacturing enterprises, also found that the growth rate of employees decreases with the age of the enterprise. The study found that firm growth tends to decrease with increasing age at market.

However, it should be noted that as the age increases, the enterprise as a whole will become more mature, but there are certain problems in directly assessing the life cycle by the age: for one thing, the age of an enterprise being able to assess the life cycle is a concept relative to itself and is not suitable for horizontal comparison. An older enterprise is not necessarily more mature than a younger one, because the industry and market environment in which the enterprise is located may cause the younger enterprise to show the characteristics of a mature enterprise. Secondly, the possibility of rebirth is not taken into account when regarding the age of an enterprise, which in turn cannot reasonably reflect the life cycle of an enterprise. In view of this, another type of commonly used measures is the retained earnings ratio and retained earnings asset ratio [48].

The shortcomings of the literature review can be concluded that: (1) there is no unified method for assessing the life cycle of enterprises. (2) The existing methods are mainly based on the evaluation of simple indicators or indicator systems and are therefore not able to reflect the ecological characteristics of life cycle. (3) The literature review lacks intuitive evaluation tools.

The objective of this paper is to: (1) construct a method for assessing the life cycle of an enterprise with ecological theory. Ecological characteristics of enterprise growth can accurately reflect the life cycle of an enterprise. (2) This paper analyzes the life cycle of sample enterprises by constructing a dynamic two-stage logistic model. (3) An intuitive evaluation matrix is designed based on the regression results of the two-stage logistic model.

This research focuses on the growth of a sample of China's automotive manufacturing enterprises, especially the decline phenomenon of these enterprises. Therefore, this study divides the life cycle of the enterprises into four stages: birth period, growth period, maturity period, and decline period.

The reasons for choosing automobile manufacturing as the research sample in this study are as follows: (1) there are many automobile manufacturing enterprises and rich research samples. (2) Under the dual pressure of energy and environment, automobile manufacturing enterprises, as traditional manufacturing enterprises, are more vulnerable to the impact of the market environment. (3) The development of new energy vehicles and the guidance of national policies affect the life cycle of traditional automobile manufacturing enterprises. (4) Data on the automobile manufacturing industry are more readily available. At the same time, the stability of the logistic model is tested. The test results show that the logistic model has more reliable applicability to different types of indicators and different types of enterprises. This method can also be applied to a variety of scenarios other than the automotive industry.

2. Methodology and Data

The development of the population in the ecosystem cannot grow indefinitely. The population dynamics model pays attention to the change in population quantity and the competition and coordination mechanism within the population. The more individuals in the population, the more intense the competition.

In a socio-economic ecosystem, the synergistic evolution among enterprises is essentially oriented towards continuous innovation. The socio-economic ecosystem, of which the synergistic evolution includes an organic mix of markets and enterprises, is viewed as a mechanism of synergistic evolution [49]. The fusion of methods is the breakthrough of current life cycle research [50]. As shown in Figure 1, this paper constructs a compound model to carry out the research. The technical methods and processes studied in this paper are shown in the figure below.

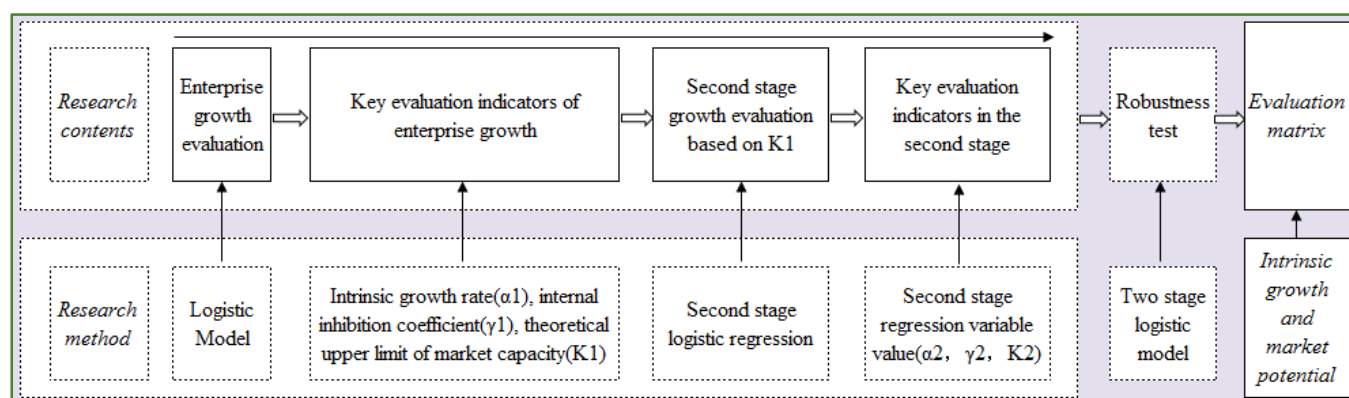


Figure 1. Study methods and processes.

2.1. Ecosystem Perspective and Population Dynamics

The ecosystem view is widely used in the research of ecology, sociology, economics, and management. Ecosystem theory can link natural ecosystem research with social ecosystem research well [51]. In the field of social science research, innovation system [52,53], education system [54], and industrial system [55] can all be explained by ecosystem theory. For example, in the automobile industry, automobile manufacturing enterprises can be regarded as a population. The symbiotic relationship can be expressed as a competitive relationship or a cooperative relationship. A collaborative relationship can promote mutual benefit and common development between enterprises. Population dynamics is one of the classical methods to describe ecological symbiosis.

Population dynamics models focus on changes in population size, variation patterns, and nonlinear growth patterns. The logistic regression model was proposed by the British statistician Cox [56]. In this paper, the products sold by an enterprise are considered as a product population [57] and the growth dynamics system is built according to a logistic model.

$$g_1(t) = \frac{dN_1(t)}{dt} = \alpha_1 N_1 \left(1 - \frac{N_1}{K_1} \right) \quad (1)$$

$g_1(t)$ is the automobile product sales' growth rate in period t ;

$N_1(t)$ is the automobile product sales' population size in period t ;

K_1 is the automobile product sales' maximum population size;

α_1 is the intrinsic growth rate;

$\left(1 - \frac{N_1}{K_1} \right)$ is the growth retardation factor.

In this study, $g_1(t)$ is the growth rate of automobile product sales in period t ; $N_1(t)$ is the sales size of automobile products in period t ; $K_1(t)$ is the theoretical maximum sales size of automotive products; and $\alpha_1(t)$ is the intrinsic growth rate of auto product sales.

Based on related studies [58,59], the following econometric model is given in this paper:

Because: $dN_1(t) \approx \Delta N_1(t)$, $\Delta N_1(t) = N_1(t) - N_1(t-1)$, $dt \approx \Delta t = t - (t-1) = 1$.

Therefore:

$$g_1(t) \approx \Delta N(t) = \alpha_1 N_1(t-1) + \gamma_1 N_1^2(t-1) \quad (2)$$

In general, $\alpha_1 > 0$ represents the synergy within an automotive product population and is called the intra-firm synergy coefficient.

When $\alpha_1 > 1$, the synergistic effect is significant.

Let $\gamma_1 = -\frac{\alpha_1}{K_1}$, usually, $\gamma_1 < 0$, represent the competitive effect within an automotive product population, called the intra-firm competition coefficient or product population density suppression coefficient. In order to test the stability of the two-stage logistic model, a stability verification model with operating income as the main variable is designed in the empirical research part.

2.2. Empirical Analysis

Under the dual pressure of resources and environment, the traditional manufacturing industry is constrained by resource constraints and carbon emission reduction. Today, when the concept of green and sustainable development is in the people's hearts, people prefer the development of low-carbon environmental protection industry [60]. The automobile manufacturing industry is an important part of the manufacturing industry. Sales and use of automobile products are affected by the carbon emission reduction policy. At the same time, the traditional automobile manufacturing industry has been impacted by the NEVs (new energy vehicles) [61]. Therefore, the life cycle of automobile manufacturing enterprises may change rapidly and dynamically under the influence of the external environment. This is also the primary reason why this paper chooses automobile manufacturing enterprises as the empirical analysis object.

This paper first uses data on total automobile sales in China as a basis for analyzing the overall assessment of the development of China's automobile industry. Then, enterprises experiencing operational difficulties in China's auto market and those having withdrawn from the market are selected as the research samples. Top-ranking enterprises were selected as the research sample for a comparative analysis. The sample of enterprises with declining operating performance includes CA-Ford and BJ-Hyundai, and the sample of delisted car manufacturers includes Lifan, Gac-Jeep, Gac-Fiat, Qoros, and Borgward, while the sample of those with mature operation and relatively large sales volume are SAIC-VW and Geely. When choosing the sample enterprises, this paper selects different types of automobile manufacturing enterprises as the research samples. These enterprises include independent brand enterprises, joint ventures, and foreign-funded enterprises. At the same time, enterprises with different operating times are selected as samples. Due to the limitation of space, the descriptive statistics of the sales data of the sample enterprises are given in this paper, and the statistical characteristics are shown in the following table.

As shown in Table 2, the sales data of sample enterprises show relatively large differences. The sample data can represent the enterprise forms at different life cycle stages. In order to further analyze the specific stages of the life cycle of the sample enterprises, this paper constructs a two-stage logistic regression analysis model. The specific research process is as follows.

(1) First-stage logistic model

In this study, the first stage of the logistic model was used to analyze the sample data for enterprise growth. In this phase, the sample data were first segmented and the logistic model regressions were conducted for each year of monthly sales data according to the era to which the sample data belonged. Due to the limitation of space, the monthly sales data of Chinese automobiles by year are given in this paper, as shown in Table 3.

Table 2. Descriptive statistics of sales data of sample companies.

	National Total Sales	SAIC-VW	Geely	CA-Ford	BJ-Hyundai	Lifan	Gac-Jeep	Gac-Fiat	Qoros	Borgward
Observations	186	186	186	186	186	170	76	72	88	60
Maximum	2,672,264	205,610	153,659	100,005	146,008	24,742	20,721	9497	7028	7153
Minimum	216,481	8400	11,391	3469	1696	2	1	1	30	1
Mean	1,564,217	99,348	57,288	36,508	58,628	6846	7740	2493	1831	2495
Standard deviation	482,967	42,495	35,877	24,966	29,053	5762	5574	2558	1738	1859

Table 3. Monthly data of total vehicle sales in China by year.

Year	Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan
2022							2,1628,39	1,577,056	942,539	1,819,813	1,451,420	2,140,089
2021	2,398,523	2,175,564	1,990,339	1,737,510	1,543,903	1,543,474	1,553,528	1,642,018	1,746,754	1,914,414	1,148,130	2,358,372
2020	2,285,751	2,098,448	2,300,447	2,075,889	1,754,600	1,664,826	1,720,593	1,673,900	1,536,600	1,039,532	216,481	1,696,520
2019	2,213,089	2,056,669	1,927,669	1,930,637	1,652,908	1,527,912	1,727,910	1,561,172	1,574,877	2,019,443	1,219,497	2,021,089
2018	2,233,108	2,173,485	2,046,840	2,060,478	1,789,871	1,589,544	1,874,181	1,889,414	1,914,369	2,168,570	1,475,512	2,456,157
2017	2,653,255	2,589,477	2,352,462	2,342,567	1,875,193	1,678,433	1,831,847	1,751,294	1,722,243	2,096,286	1,632,748	2,218,215
2016	2,672,264	2,590,157	2,344,128	2,268,338	1,795,512	1,604,530	1,784,053	1,793,035	1,779,130	2,055,706	1,376,681	2,228,705
2015	2,442,126	2,196,773	1,936,875	1,751,215	1,418,462	1,268,597	1,511,439	1,609,274	1,668,824	1,870,357	1,396,733	2,038,003
2014	2,061,044	1,775,320	1,708,861	1,696,001	1,468,166	1,357,948	1,564,117	1,590,354	1,609,035	1,710,067	1,312,197	1,846,846
2013	1,776,937	1,696,278	1,605,748	1,593,512	1,353,235	1,237,596	1,403,453	1,396,871	1,441,441	1,585,509	1,111,892	1,725,525
2012	1,462,874	1,461,303	1,605,980	1,617,358	1,218,884	1,120,206	1,284,175	1,607,200	1,647,600	1,880,600	1,213,100	1,389,800
2011	1,689,600	1,656,000	1,524,822	1,646,100	1,381,100	1,275,300	1,435,900	1,382,800	1,552,000	1,828,500	1,267,000	1,894,300
2010	1,666,700	1,967,000	1,538,600	1,556,700	1,322,000	1,244,000	1,412,100	1,438,000	1,555,000	1,735,000	1,234,000	1,664,000
2009	1,413,700	1,337,700	1,226,300	1,331,800	1,138,500	1,085,600	1,142,000	1,120,000	1,153,000	1,110,000	828,000	735,000
2008	740,000	690,000	720,000	750,000	630,000	670,000	840,000	840,000	920,000	1,060,000	660,000	860,000
2007	840,000	800,000	690,000	770,000	670,000	640,000	730,000	710,000	810,000	850,000	550,000	720,000

As shown in Table 3, there is a clear growth process for total vehicle sales in China. Monthly sales are basically stable for the same period each year from 2018 to 2021. China's auto sales have obvious seasonal fluctuations. July and August are low seasons for sales, and January and December are peak seasons for sales. The regression results of the sample data are shown in Table 4.

As shown in Table 4, the first-stage logistic model regression model for total sales of the Chinese auto market works relatively well. The total sales volume of China's auto market has shown a booming momentum. The intrinsic growth rate of the auto market has been maintained at positive values, with the intrinsic growth rate reaching above 1 in 2007, 2011, and 2013. The value of the internal inhibition coefficient of the auto market has remained in a reasonable range. From 2007 to 2011, the internal inhibition coefficient gradually increased. The internal inhibition coefficient gradually decreased from 2012 to 2017. From 2018 to 2022, the internal inhibition coefficient rose amid turbulence. This indicates that the competition in the auto market has intensified in recent years, and the theoretical upper limit of the auto market capacity has increased significantly from 2007 to 2022. From 2007, 740,000 sales per month rose to a market capacity ceiling of 2.11 million units in 2017. From 2018 to 2022, the market experienced a small turbulence and remained at a level of about 1.8 million units per month. In summary, the Chinese auto market remained in the development period from 2007 to 2017. China's auto market entered the maturity period after 2018.

Table 4. Upper limit of theoretical values of monthly sales of automobiles in China.

Year	Intrinsic Growth Rate (α_1)	Internal Inhibition Coefficient (γ_1)	Theoretical Upper Limit of Sales Volume (K_1)
2022	0.879 (1.374)	-4.926×10^{-7} (−1.540)	1,784,317
2021	0.801 (2.195) **	-4.268×10^{-7} (−2.286) **	1,876,178
2020	0.392 (0.644)	-2.281×10^{-7} (−0.727)	1,718,278
2019	0.929 (2.436) **	-5.093×10^{-7} (−2.520) **	1,824,591
2018	0.757 (2.661) **	-3.776×10^{-7} (−2.829) ***	2,007,332
2017	0.396 (1.454) *	-1.878×10^{-7} (−1.521) *	2,114,168
2016	0.406 (1.181)	-1.936×10^{-7} (−1.211)	2,101,360
2015	0.330 (0.966)	-1.767×10^{-7} (−0.950)	1,870,568
2014	0.852 (2.023) *	-5.127×10^{-7} (−2.015) *	1,662,429
2013	1.052 (2.719) **	-6.953×10^{-7} (−2.725) **	1,514,122
2012	0.787 (2.356) **	-5.298×10^{-7} (−2.472) **	1,485,556
2011	1.113 (3.494) ***	-7.094×10^{-7} (−3.571) ***	1,569,069
2010	0.842 (2.639) **	-5.403×10^{-7} (−2.672) **	1,558,485
2009	0.343 (1.788) *	-2.611×10^{-7} (−1.572) *	1,315,140
2008	0.653 (2.044) *	-8.233×10^{-7} (−2.158) *	793,564
2007	1.057 (2.473) **	-1.427×10^{-6} (−2.482) **	740,539

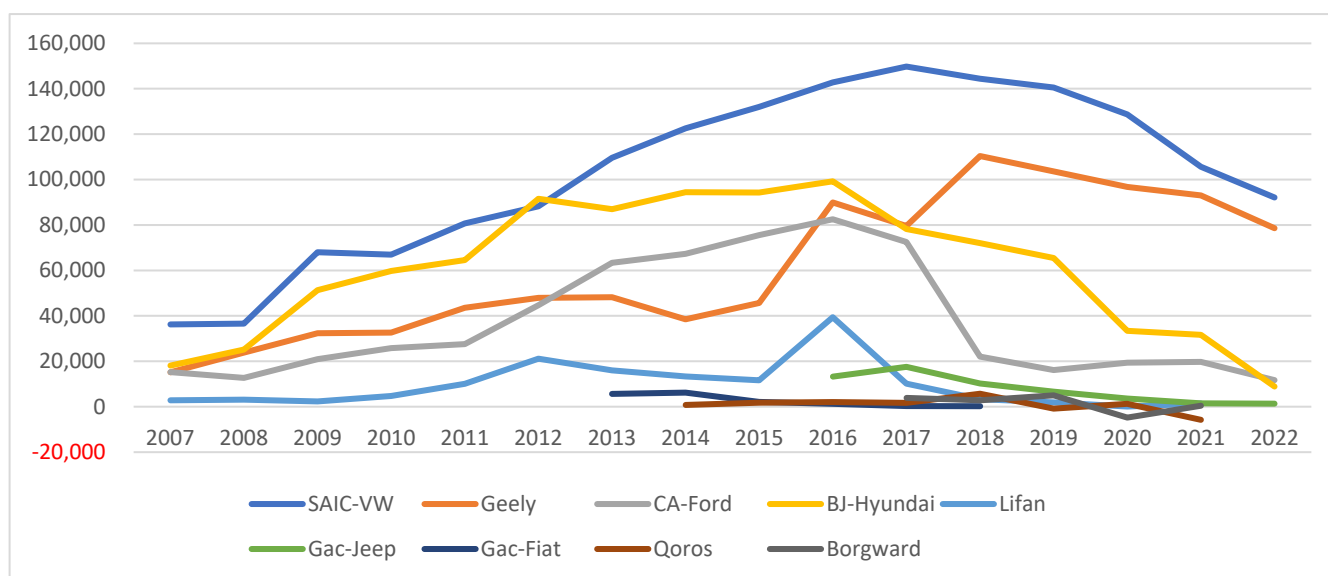
Note: () t value, * p value < 0.1, ** p value < 0.05, *** p value < 0.01.

As shown in Table 5, the sample data are segmented based on the year difference in the observed data, and the population parameter of different years are calculated, respectively. Table 5 shows the theoretical upper limit of the population, which, in this paper, represents the theoretical upper limit of the sales volume of the enterprise. Observing the data in Table 5, it can be found that the maximum upper limit of sales volume for the majority of firms occurred in 2016 or 2017. This is basically in line with the trend of the overall sales volume of China's auto market. The K values of individual firms appear to be less than 0, which is caused by their intrinsic growth rate and internal inhibition coefficient both being less than 0. In real life, one does not usually encounter a negative sales volume situation, such as a firm experiencing a large number of consumer returns. Auto companies, such as Lifan, Gac-Jeep, Gac-Fiat, Qoros, and Borgward, tend to choose to abandon the market when sales decline severely, or even when sales are zero. The theoretical upper limit of sales for each of these enterprises is so low that there is practically no need to continue their production operations. One of the main objectives of this study is to construct a methodology for analyzing the decline measures of the firms, and therefore the second stage of logistic model regression analysis is conducted in this paper. The theoretical upper limit (K_1) of the population measured in the first stage is the most important object of analysis in the second stage of the analysis.

As shown in Figure 2, the enterprises with a higher theoretical upper limit of sales volume are above the trend line in the figure. From 2007 to 2017, the theoretical upper limit of sales volume of most sample automobile enterprises was steadily increasing, and these enterprises were in the growth period. At the same time, this period was also a period of steady increase in the total volume of China's automobile market. After 2018, the theoretical upper limit of sales volume of the sample enterprises decreased to varying degrees. Since 2020, the theoretical upper limit of sales volume has decreased significantly, which is mainly due to the direct impact of the epidemic and its prevention and control measures on the production and sales of the automobile market. The whole automobile market is waiting for a chance to recover.

Table 5. Theoretical upper limit of sales volume (K_1).

Year	SAIC-VW	Geely	CA-Ford	BJ-Hyundai	Lifan	Gac-Jeep	Gac-Fiat	Qoros	Borgward
2022	92,109	78,576	11,730	8938		1404			
2021	105,638	93,034	19,710	31,621	1403	1456		−5738	421
2020	128,655	96,790	19,370	33,423	80	3606		1238	−4765
2019	140,509	103,614	16,164	65,487	1915	6627		−821	5015
2018	144,375	110,423	22,085	71,996	3280	10,237	241	5731	2787
2017	149,811	79,540	72,534	78,236	10,160	17,605	292	1662	3898
2016	142,810	89,925	82,560	99,290	39,441	13,260	1243	2022	
2015	131,981	45,686	75,553	94,268	11,637		2108	1761	
2014	122,531	38,445	67,306	94,408	13,310		6251	743	
2013	109,591	48,195	63,347	86,933	16,033		5661		
2012	88,246	47,917	44,707	91,512	21,174				
2011	80,702	43,587	27,533	64,576	10,083				
2010	66,978	32,608	25,776	59,774	4745				
2009	67,985	32,374	20,910	51,338	2319				
2008	36,593	23,824	12,654	25,127	3084				
2007	36,250	15,177	15,214	18,135	2798				

**Figure 2.** Change trend of theoretical upper limit of sales volume of sample enterprises.

(2) Second-stage logistic model

In this stage, logistic model regression analysis was conducted using the theoretical upper limits of sales volume in the maturity and decline periods of the enterprises, focusing on exploring the population dynamics mechanism in the decline period of the enterprises and summarizing the ecological characteristics of mutually declining enterprises. The model regression results are shown in the following table.

As shown in Table 6, the sales of the above sample enterprises can be classified based on the positive or negative intrinsic growth rate (α_2), internal inhibition coefficient (γ_2), and theoretical market capacity (K_2). The first category is Geely and CA-Ford, who have an intrinsic growth rate greater than zero, an internal inhibition coefficient less than zero, and a theoretical market capacity greater than zero. The values of the correlation regression coefficients of the first category are taken strictly in accordance with the theoretical requirements of population ecology. Among them, Geely is doing well, and its theoretical market

capacity is relatively high. The endowment growth rate of CA-Ford is low in intrinsic growth rate, which has approached zero, which also leads to its theoretical market capacity of only 5731 sales volume per month as the upper limit.

Table 6. Upper limit of theoretical values of monthly sales data of Chinese automobiles.

Enterprise	Intrinsic Growth Rate (α_2)	Internal Inhibition Coefficient (γ_2)	Theoretical Upper Limit of Sales Volume (K_2)
SAIC-VW	−0.489 (−2.163) *	2.966×10^{-6} (1.809)	164,843
Geely	1.086 (1.540)	-1.115×10^{-5} (−1.569)	97,510
CA-Ford	0.059 (0.359)	-1.043×10^{-5} (−4.058) **	5731
BJ-Hyundai	−0.735 (−1.388)	7.643×10^{-6} (0.999)	96,189
Lifan	−0.632 (−5.405) ***	-2.779×10^{-6} (−0.904) ***	−22,7807
Gac-Jeep	−0.407 (−4.130) **	-2.030×10^{-7} (−0.031) *	−200,7569
Gac-Fiat	−0.137 (−0.128)	-3.425×10^{-5} (−0.184)	−4012
Qoros	−0.523 (−0.239)	-9.843×10^{-5} (−0.231)	−5314
Borgward	−0.985 (−1.501)	-2.113×10^{-5} (−0.145)	−46,638

Note: () t value, * p value < 0.1, ** p value < 0.05, *** p value < 0.01.

The second category is SAIC-VW and BJ-Hyundai, who have an intrinsic growth rate less than zero, an internal inhibition coefficient greater than zero, and a theoretical market capacity greater than zero. The theoretical market capacity of these two enterprises is still relatively high, reaching 164,843 (SAIC-VW) and 96,189 (BJ-Hyundai) per month, respectively. It would be one-sided to evaluate these two companies simply by the actual monthly sales and the theoretical sales online. The sales figures for these two enterprises are promising, but they face many dilemmas in their actual operations. This dilemma is reflected by the values of the intrinsic growth rate (α_2) and the internal inhibition coefficient (γ_2). The ecological analysis shows that the internal resources of these two enterprises cannot support their relatively high intrinsic growth rates. In the case of SAIC-VW and BJ-Hyundai, the internal resources of these two enterprises cannot support new product development, competitive advantage maintenance, or market share maintenance and expansion. This situation is especially evident in China's rapidly growing new energy vehicle market. SAIC-VW's resources and capabilities are much higher than BJ-Hyundai's, and the internal inhibition coefficient is greater than 0, indicating that both enterprises have high levels of internal synergy, division of labor, and management efficiency. The high level of internal management makes up for the lack of intrinsic growth rate.

The third category is Lifan, Gac-Jeep, Gac-Fiat, Qoros, and Borgward. These enterprises have an intrinsic growth rate and an internal inhibition coefficient less than 0, so the theoretical market capacity also shows a negative value. Negative market capacity indicates that these enterprises should choose bankruptcy and liquidation, restructuring, or withdraw from this market. The internal resources and capabilities are not sufficient to maintain their product sales and market share, and there is significant internal competition and internal consumption within the enterprises. The actual market performance and management decisions of these enterprises also validate the model parameter regression results. These enterprises did not perform well in the Chinese market and eventually withdrew from the market. Among them, Lifan chose to restructure and Qoros and Borgward chose to exit this market. Gac-Jeep and Gac-Fiat also chose to quit the path of localized production in China. On 18 July 2022, according to GAC and Stellantis news, the parties are negotiating an orderly termination of the joint venture due to GAC-Fiat's continued losses in recent years and its inability to resume normal production operations since February 2022. In the future, Stellantis Group will only retain the import business of the Jeep brand in China; the domestically produced Jeep will cease to exist and consumers will still be able to purchase imported Jeep products. In the era of rapid expansion of the Chinese auto market, the SUV-focused Gac-Jeep took good advantage of the market when after a period of hibernation, it quickly went on to glory. Gac-Jeep is one of those companies that started

to fall fast after China's auto market entered the era of stock competition, and the fate of the Fiat and the Jeep brand in China was somewhat similar, with Gac-Fiat turning down sharply after achieving its best annual sales performance in 2014, with less than 3000 units left in 2017.

Although the size of China's auto market is still very large, the era "on the gravy train" has long become a thing of the past. In recent years, foreign parties, including Changan Suzuki, Dongfeng Renault, Chang'an PSA, and other joint venture brands, have announced their withdrawal from the Chinese market. Early in 2022, Guangzhou Automobile Acura also rumored the intention to withdraw from the Chinese market. Suzuki, one of the first auto enterprises to enter China, established joint ventures with Chang'an and Changhe in the 1990s. However, in 2018, in order to quickly end the performance drag of the Chinese joint venture, Suzuki even transferred its shares of Chang'an Suzuki to Chang'an Group for only USD 1. The French brand Renault, known for its individuality, also established a joint venture with Dongfeng in 2013. After that, the domestic Koleos and Kadjar products were successively launched, but the sales fell rapidly after a short climbing period, and they opted out in 2020.

The repeated entry into and exit from the Chinese market of some foreign auto brands reflects the charm and full competitiveness of the Chinese market. The withdrawal of weak foreign auto brands reflects that the Chinese auto market has entered a period of elimination of the best and the worst, and warns other joint venture brands to invest more energy in product localization and technological innovation. The life cycle of the Chinese auto industry is in a mature stage and is large in scale, but the life cycle of auto companies does not necessarily align with the industry cycle. The two-stage logistic model developed in this paper can be used to make a better determination of the life cycle in which an enterprise is located, which helps automotive manufacturers to make more accurate decisions.

(3) Evaluation matrix of intrinsic growth and market potential

In order to more intuitively show the practical significance of the regression results of the two-stage logistic model, this paper constructs a two-coordinate evaluation matrix. This evaluation matrix is somewhat similar to the Boston matrix. The abscissa of the matrix is the intrinsic growth rate (α_2). The ordinate of the matrix is the theoretical market capacity (K_2). Here, this paper defines the theoretical market capacity (K_2) as the market potential variable. The two coordinates divide the whole coordinate system into four quadrants, as shown in Figure 3.

As shown in the Figure 3, each quadrant has the following meanings.

Quadrant 1: Enterprises in this quadrant are in the growth period. During this period, the intrinsic growth rate of enterprises' products was high, and the theoretical upper limit of market sales was also high, which was in a state of double high.

Quadrant 2: Enterprises in this quadrant are in the mature stage. During this period, the intrinsic growth rate of enterprise products was low, but the theoretical upper limit of market sales was high.

Quadrant 3: Enterprises in this quadrant are in recession. During this period, the intrinsic growth rate of enterprise products was low, and the theoretical upper limit of market sales was also low, which was in a state of double low.

Quadrant 4: Enterprises in this quadrant are in the import period. During this period, the new products of the enterprise just came into the market, and the intrinsic growth rate of its products was high, but the theoretical upper limit of market sales was small.

Enterprises located at the edge of the quadrant may migrate to the adjacent quadrant. Enterprises in the import period may migrate to the growth period or the recession period. If the enterprise's operation measures are appropriate, it will move to the growth period. The normal development of enterprises in the growth stage will migrate to the mature stage. However, if the enterprise makes a wrong management decision, the enterprise may guide the entry migration. This is the situation that enterprises are facing in a second venture.

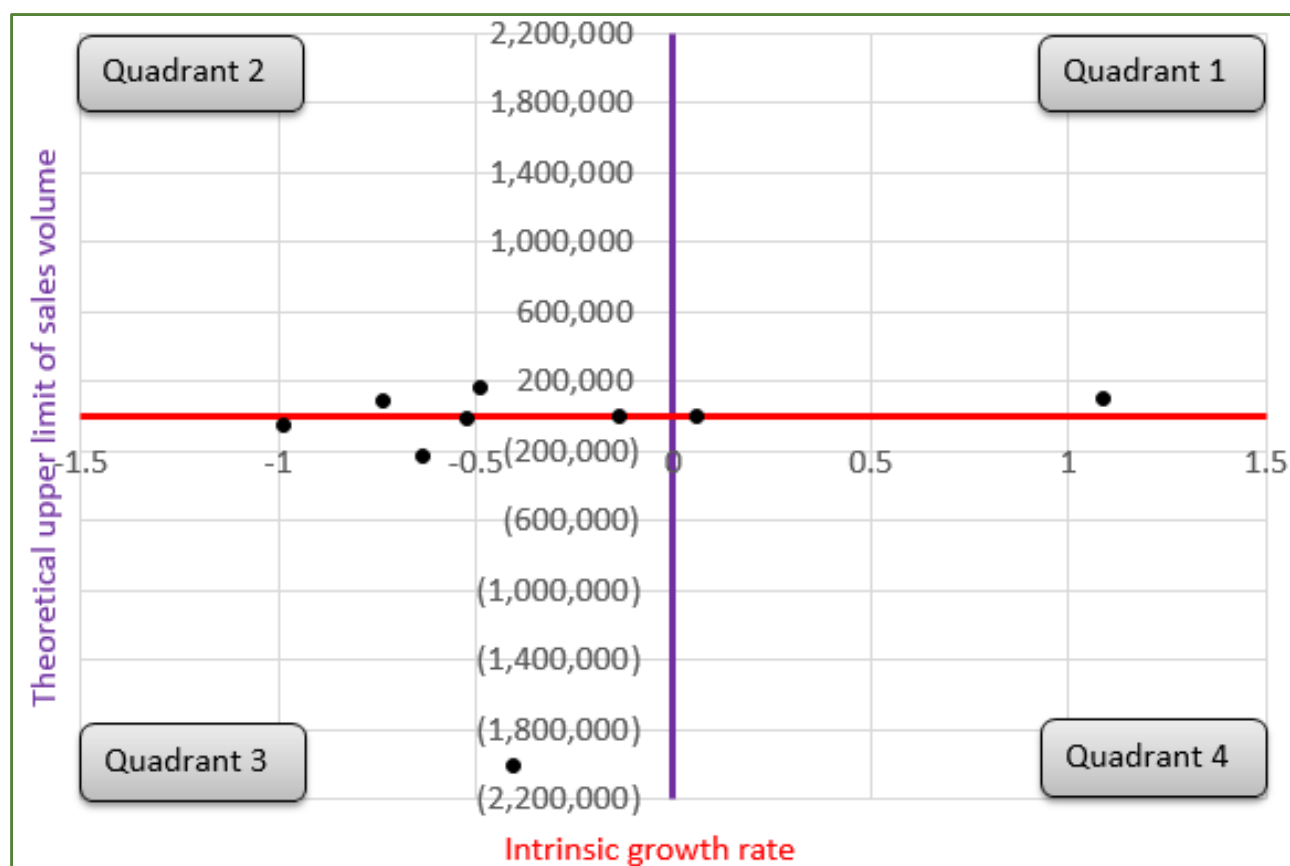


Figure 3. Evaluation matrix of intrinsic growth and market potential.

Some special values may appear in the model operation. Generally, the reliability of data results can be improved by increasing the number of observation values. Due to the large jeep in the measured value of the model in this paper, the coordinate points of other enterprises in the figure are relatively concentrated. In order to improve the recognition between enterprises, we draw the jeep data again after it is presented. The new figure is shown below.

Looking at the Figure 4, we can find that after excluding special values, the positions determined by the two-coordinate data of other enterprises are relatively scattered. The life cycle judgment of different enterprises can be directly given based on the quadrants of the enterprises. It can be seen that Geely and CA-Ford are in the growth stage, SAIC-VW and BJ-Hyundai are in the mature stage, and Fiat, Qoros, Borgward, and Lifan are in the decline stage. Different enterprises can adjust their operational strategies and strategies based on their own life cycles.

2.3. Robustness Test of Logistic Model

In this paper, the robustness of the model is tested by using a single enterprise with multiple indicators and a single indicator with multiple enterprise scenarios. In the stability test of the single-enterprise multi-index model, diversified financial indicators are comprehensively used to illustrate the stability of the model. These financial indicators include main business income, intangible assets, and employee wages, which can reflect the enterprise characteristics of different life cycles. The data required in this section were taken from the Securities Star website [62].

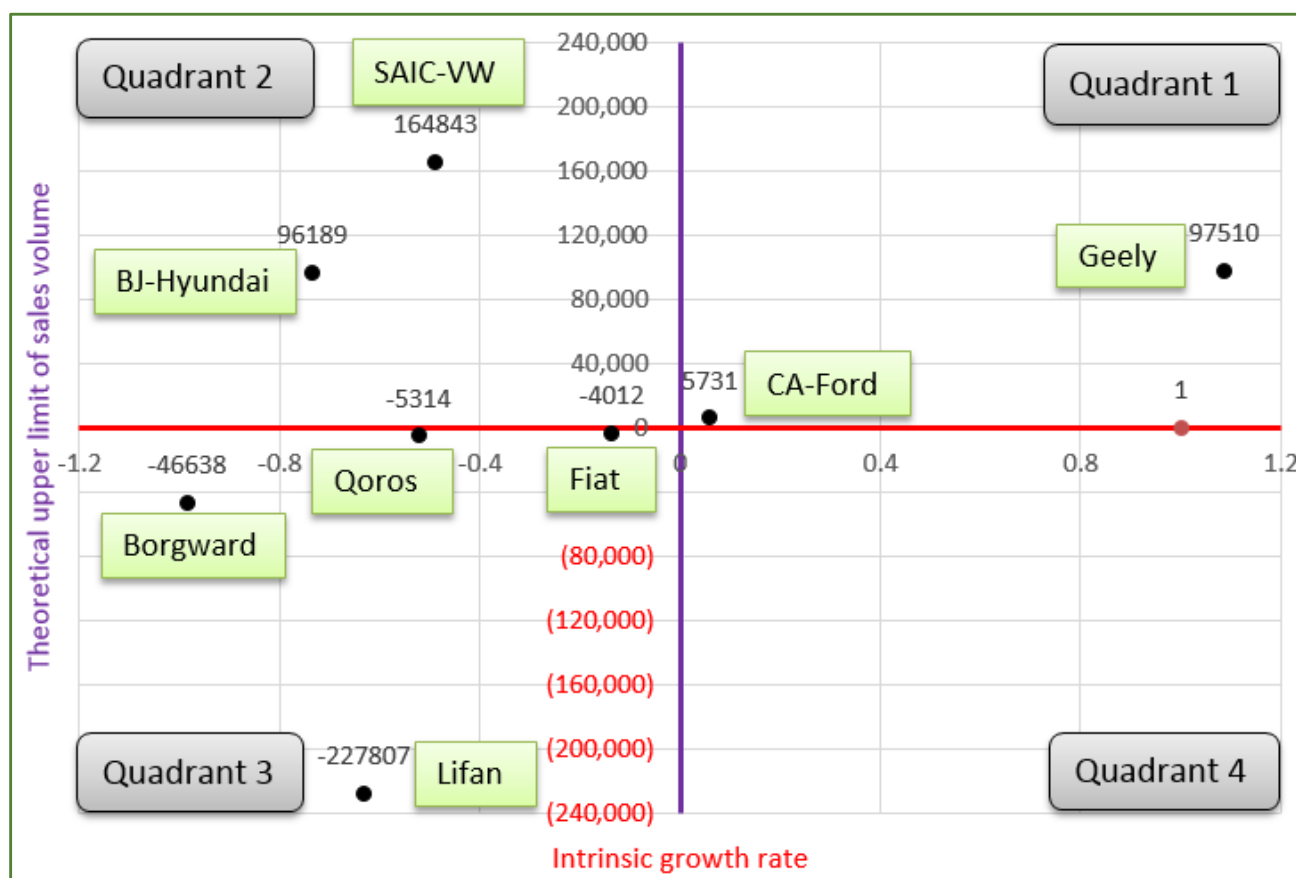


Figure 4. Evaluation matrix after excluding special values.

(1) Multi-indicator test for a single enterprise

In order to verify the robustness of the logistic model, this paper uses a case of model validation analysis with a changed sample, changed main indicators, and changed observation period.

The research variables need to be changed during the stability test, but the key financial data of many automobile manufacturing enterprises are difficult to obtain. Therefore, this paper selects the financial data of listed companies in the automobile manufacturing industry for analysis. BYD Company is a rising star in the automobile manufacturing industry, and its market value ranks first among similar enterprises. The main business income of an automobile manufacturing enterprise is the index data corresponding to the total sales volume. In general, the total sales volume and main business income of an automobile manufacturing enterprise are indicators that change in the same direction. Automobile sales volume is a pure quantitative and scale indicator. The main business income contains more complicated information.

In this paper, the main business revenue, intangible assets, and employee compensation data of BYD Company are selected as the sample data for a single logistic model analysis. The main business revenue data for the study are shown in the following table.

As shown in Table 7, BYD's main business revenue shows a continuous upward trend. A logistic regression model is used to analyze the sample data to see if this upward trend is sustainable. The results of the study are shown in the table below.

Table 7. Main business revenue of BYD (unit: Yuan).

Report Date	Main Business Revenue	Report Date	Main Business Revenue	Report Date	Main Business Revenue	Report Date	Main Business Revenue
Mar 2022	66,825,185,000	Mar 2019	30,304,111,000	Mar 2016	20,285,247,000	Mar 2013	12,883,871,000
Dec 2021	216,142,395,000	Dec 2018	130,054,707,000	Dec 2015	80,008,968,000	Dec 2012	46,904,292,000
Sep 2021	145,192,358,000	Sep 2018	88,981,326,000	Sep 2015	48,493,574,000	Sep 2012	33,108,940,000
Jun 2021	90,885,400,000	Jun 2018	54,150,930,000	Jun 2015	31,582,366,000	Jun 2012	22,582,012,000
Mar 2021	40,991,873,000	Mar 2018	24,737,565,000	Mar 2015	15,282,504,000	Mar 2012	11,734,272,000
Dec 2020	156,597,691,000	Dec 2017	105,914,702,000	Dec 2014	58,195,878,000	Dec 2011	48,826,919,000
Sep 2020	105,022,633,000	Sep 2017	73,932,895,000	Sep 2014	40,408,603,000	Sep 2011	34,334,089,000
Jun 2020	60,502,986,000	Jun 2017	45,037,637,000	Jun 2014	26,715,706,000	Jun 2011	22,544,664,000
Mar 2020	19,678,542,000	Mar 2017	21,046,138,000	Mar 2014	11,723,871,000	Mar 2011	11,710,335,000
Dec 2019	127,738,523,000	Dec 2016	103,469,997,000	Dec 2013	52,863,284,000	Dec 2010	48,448,416,000
Sep 2019	93,821,797,000	Sep 2016	72,797,790,000	Sep 2013	38,704,489,000	Dec 2009	41,113,912,000
Jun 2019	62,184,263,000	Jun 2016	44,949,565,000	Jun 2013	26,040,933,000	Dec 2008	27,727,209,000

(https://stock.quote.stockstar.com/finance/profit_002594.shtml (accessed on 1 May 2022)).

As shown in Table 8, the regression of the model is good, and a relatively good fit can be obtained for data of different time periods. This indicates that the population dynamics model can also be used well with the main business revenue data of the enterprise. The theoretical upper limit of BYD's main business revenue is also gradually increasing from 2010 to 2022, which indicates that BYD's main business is still in the rising stage, and it is in the growth stage of its life cycle. BYD's development process is actively pushing innovation-driven and market-driven methods with the help of globalization resources. BYD's intrinsic growth rate is adjusted downward in the oscillation, and its internal restraint coefficient shows a regular decline. The decline in the internal inhibition coefficient mainly relies on management innovation and management efficiency improvement. The high level of management reduces the internal consumption of the enterprise and allows the synergistic development of all departments within the enterprise. The intangible asset data of BYD Company was selected as the sample data for a single logistic model analysis. The sample data for the study are shown in the following table.

Table 8. Upper limit of theoretical value of BYD main business revenue data.

Income Report Period	Intrinsic Growth Rate (α_1)	Internal Inhibition Coefficient (γ_1)	Theoretical upper Limit of Business Revenue (K_1)
2010–2022	0.574 (2.623) ***	$-5.931 \times 10^{-6} (-4.162)$ ***	85,543,722,701
2020–2022	1.129 (1.857) *	$-8.876 \times 10^{-12} (-2.429)$ **	127,272,881,597
2017–2019	1.855 (4.408) ***	$-2.105 \times 10^{-11} (-5.028)$ ***	88,129,201,177
2014–2016	1.157 (1.840) *	$-2.056 \times 10^{-11} (-2.035)$ *	56,314,432,274
2010–2013	2.039 (6.494) ***	$-5.448 \times 10^{-11} (-7.064)$ ***	37,427,458,675

Note: () t value, * p value < 0.1, ** p value < 0.05, *** p value < 0.01.

As shown in Table 9, BYD's intangible assets show a continuous upward trend. A logistic regression model was used to analyze the sample data to see if this upward trend sustainable. The results of the study are shown in the table below.

Table 9. Total intangible assets of BYD (unit: hundred million Yuan).

Report Date	Intangible Assets	Report Date	Intangible Assets	Report Date	Intangible Assets
Mar 2022	159.1	Sep 2019	127.3	Mar 2017	89.9
Dec 2021	171.0	Jun 2019	121.9	Dec 2016	89.5
Sep 2021	149.8	Mar 2019	119.5	Sep 2016	90.5
Jun 2021	149.7	Dec 2018	113.1	Jun 2016	89.5
Mar 2021	154.4	Sep 2018	108.2	Mar 2016	90.7
Dec 2020	118.0	Jun 2018	104.2	Dec 2015	87.9
Sep 2020	118.8	Mar 2018	99.4	Sep 2015	90.1
Jun 2020	120.2	Dec 2017	101.0	Jun 2015	86.9
Mar 2020	126.5	Sep 2017	92.0	Mar 2015	84.0
Dec 2019	126.5	Jun 2017	92.3		

As shown in Table 10, the regression of the model is good, and this indicates that the logistic model can also be used well with the intangible asset data of the enterprise.

Table 10. Upper limit of theoretical value of BYD's intangible asset data.

Income Report Period	Intrinsic Growth Rate (α_1)	Internal Inhibition Coefficient (γ_1)	Theoretical Upper Limit of Intangible Assets (K_1)
2015–2022	0.087 (1.245)	-5.365×10^{-4} (−0.949) ***	162.6
2021–2022	1.142 (3.695) **	-7.220×10^{-3} (−3.577) **	158.2
2019–2020	0.551 (2.080) *	-4.487×10^{-3} (−2.065) *	123.0
2017–2018	−0.008 (−0.043)	3.994×10^{-4} (0.201)	21.2
2015–2016	0.811 (3.452) **	-9.059×10^{-3} (−3.417) **	89.6

Note: () t value, * p value < 0.1, ** p value < 0.05, *** p value < 0.01.

As shown in Table 11, the employee compensation of BYD Company was in a steady growth trend during the observation period. The total remuneration increased from CNY 738 million in September 2010 to CNY 6.693 billion in June 2022. The logistic regression results of total remuneration are shown in the following table.

As shown in Table 12, although the regression results here are not as good as the first two variables, the theoretical upper limit value is still within a reasonable range, and the regression results are still of good reference value.

(2) Single indicator multi-enterprise test

In order to better test the stability of the logistic regression model, this section selects the main business data of eight well-known listed companies from different industries for robustness analysis. Relevant data were taken from Securities Star website [62], and observation data were selected from March 2015 to March 2022.

Shown in Table 13 are the statistical characteristics of the main business income data of the sample enterprises. The logistic regression results are shown in the following table.

As shown in Table 14, the regression effect of the model is very good. The validation case in this subsection fully illustrates the robustness of the logistic model, which still works well under heterogeneous sample and data conditions.

Table 11. Total Employee compensation of BYD (unit: hundred million Yuan).

Report Date	Employee Compensation	Report Date	Employee Compensation	Report Date	Employee Compensation
Jun 2022	66.93	Jun 2018	34.79	Jun 2014	13.40
Mar 2022	60.58	Mar 2018	32.20	Mar 2014	12.77
Dec 2021	58.49	Dec 2017	31.80	Dec 2013	12.85
Sep 2021	51.30	Sep 2017	29.20	Sep 2013	13.07
Jun 2021	45.04	Jun 2017	26.44	Jun 2013	13.08
Mar 2021	45.30	Mar 2017	24.45	Mar 2013	12.93
Dec 2020	48.35	Dec 2016	29.79	Dec 2012	12.94
Sep 2020	50.16	Sep 2016	22.53	Sep 2012	11.21
Jun 2020	52.08	Jun 2016	20.06	Jun 2012	11.61
Mar 2020	38.62	Mar 2016	18.40	Mar 2012	13.05
Dec 2019	37.83	Dec 2015	21.18	Dec 2011	12.82
Sep 2019	41.48	Sep 2015	17.82	Sep 2011	11.54
Jun 2019	39.22	Jun 2015	17.28	Jun 2011	10.79
Mar 2019	40.62	Mar 2015	15.98	Mar 2011	10.54
Dec 2018	38.56	Dec 2014	14.71	Dec 2010	10.03
Sep 2018	38.02	Sep 2014	14.08	Sep 2010	7.38

Table 12. Upper limit of theoretical value of BYD's employee compensation data.

Income Report Period	Intrinsic Growth Rate (α_1)	Internal Inhibition Coefficient (γ_1)	Theoretical Upper Limit of Employee Compensation (K_1)
2020–2022	0.190 (0.719)	−0.002 (−0.513)	71.81
2017–2019	0.186 (1.134)	−0.004 (−1.047)	38.94
2014–2016	−0.130 (−0.602)	0.012 (1.038)	10.58
2010–2013	0.579 (4.475) ***	−0.046 (−7.064) ***	12.57

Note: () t value, *** p value <0.01.

Table 13. Descriptive statistics of main business income data of sample companies.

Enterprise	Observations	Maximum	Minimum	Mean	Standard Deviation
ZTE	29	114,521,641,000	20,998,792,000	59,519,029,448	29,235,197,512
TCL Technology	29	163,690,642,125	13,789,536,228	64,130,762,530	35,689,533,988
BOE	29	219,309,799,505	11,582,854,379	66,607,987,566	47,343,240,400
Zoomlion	29	67,130,626,817	3,023,695,827	23,237,289,122	17,400,438,523
XCMG	29	84,327,579,230	3,477,641,893	29,080,075,508	21,846,327,191
Weichai Power	29	203,547,703,297	17,538,925,459	92,666,003,561	53,923,999,804
Fuyao glass	29	23,603,063,361	3,223,767,646	11,384,151,323	5,840,694,341
Ningde Era	29	130,355,796,360	1,454,385,692	23,511,103,384	26,865,093,440

Table 14. Upper limit of theoretical value of sample enterprises.

Enterprise	Intrinsic Growth Rate (α_1)	Internal Inhibition Coefficient (γ_1)	Theoretical Upper Limit of Business Revenue (K_1)
ZTE	1.765 (8.419) ***	-2.340×10^{-11} (-9.797) ***	75,412,615,684
TCL Technology	0.919 (3.468) ***	-1.110×10^{-11} (-4.534) ***	82,793,836,638
BOE	0.541 (2.175) **	-5.528×10^{-12} (-3.266) ***	97,808,422,435
Zoomlion	0.732 (2.612) **	-2.009×10^{-11} (-3.614) ***	36,454,859,549
XCMG	0.820 (3.061) ***	-1.718×10^{-11} (-3.959) ***	47,737,099,876
Weichai Power	1.210 (4.493) ***	-9.542×10^{-12} (-5.436) ***	126,908,983,054
Fuyao glass	1.534 (6.344) ***	-1.046×10^{-10} (-7.503) ***	14,675,393,741
Ningde Era	0.520 (2.144) **	-8.149×10^{-12} (-3.310) ***	63,847,875,589

Note: () t value, ** p value <0.05, *** p value <0.01.

3. Results and Discussion

This study applies life cycle analysis based on ecological and population dynamics theories to the automotive enterprises. The sales volume data were considered as the size of the automobile products' population, and a two-stage logistic model was constructed to analyze the auto sales data of the sample enterprises. On the basis of the population dynamics growth mechanism study, the automotive enterprises growth mechanisms are discussed.

The results show that when the intrinsic growth rate of a firm is greater than 0, the internal inhibition coefficient is less than 0, and the theoretical market capacity is sufficient, the firm is at the maturity stage. When the intrinsic growth rate is less than 0, the internal inhibition coefficient is greater than 0, and the theoretical market capacity is sufficient, the enterprise is at the critical point of maturity and decline. This is the point where enterprises need to raise their vigilance, carefully analyze the situation, and find the right countermeasures. When the intrinsic growth rate is less than 0, the internal inhibition coefficient is less than 0, and the theoretical market capacity is insufficient, the enterprise is in decline and is coming to the end of its life cycle. This is the time when the enterprise needs to seek bankruptcy and liquidation or M&A and restructuring.

The most important feature of this study, compared with the traditional study of enterprise life cycle measurement, is that it explores life cycle based on ecological and population dynamics approaches. In the field of social economy and management, scholars have widely used the life cycle concept, but the research with the help of ecological theories and methods is not very deep.

Compared with the traditional life cycle measurement methods [31–33], this paper presents the perspective and method of a symbiotic system. Compared with the life cycle measurement method based on complex financial data of enterprises [34–39], the research method in this paper is simple and easy to implement, and the data are more easily available and the model fits better. Compared with the age-based life cycle measurement method [42–44], this paper can analyze the different survival characteristics and development mechanisms of enterprises in the same life cycle. Compared with the life cycle measure based on employee growth rate [45–47], the measure based on logistic regression of sales volume in this paper is more direct and reasonable.

4. Conclusions

The purpose of this paper is to construct a method for measuring the life cycle of an enterprise, and ecological characteristics of enterprise growth can accurately reflect the life cycle of the enterprise. The research objective of this paper also includes building a dynamic evaluation and interactive evaluation model of the life cycle and providing an intuitive evaluation tool. This paper achieves the above research objectives and shows that the logistic model of population dynamics is a good measure of the life cycle of an

enterprise. The two-stage logistic model measures the life cycle dynamics of an enterprise better, especially in the decline stage.

The theoretical highlights of this paper are as follows: (1) the logistic model based on population dynamics theory develops a new method for measuring the life cycle of a firm. (2) Using the first-stage logistic model to measure the parameters reflecting the growth of automobile products, and based on the values of the parameters of the first-stage model, the development trend of the enterprise is studied. (3) Using the second-stage logistic model to process the data of the theoretical upper limit of sales volume, the intrinsic growth rate, internal inhibition coefficient, and the theoretical upper limit of sales volume of the second-stage model are measured. The life cycle characteristics of the enterprise development are summarized based on the parameter values of the second-stage model. Highlights of this study in practice are: (1) this paper constructs an evaluation matrix of intrinsic growth and market potential and provides an intuitive life cycle evaluation method. (2) The evaluation matrix proposed in this paper can be widely used in enterprise strategic analysis and management, project evaluation and management, market research, product development, and other management practices. The main defect of this study is that the sample size is relatively small, and only the automobile manufacturing enterprises are studied. In future research, we can expand the sample size of the research sample and use big data, comparative analysis, and other means to carry out research.

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