

Chapter 2

Literature Information Growth Law

2.1 Characteristics of Literature Information Flow and Meaning of Growth Law

2.1.1 *Characteristics of Literature Information Flow*

In informetrics, the flow of information in a document is typically called literature information flow. Literature is the most basal carrier of intelligence. Document information flow is a collection of scientific literature with the characteristics of a series of themes. Literature information flow is sometimes called literature flow, for short.

Literature information flow has many features that are divided into two aspects, namely, static and dynamic characteristics. Scientific literature in the spatial distribution of properties within a certain period is called the static characteristic of literature information flow, such as concentration–discrete distribution, literature distribution according to the author, word distribution in the literature, citation distribution, and topic distribution regularity.

The continuation of scientific literature over time and the nature of growth and aging denote the dynamic characteristic of literature information flow. Scientific literature both grows and ages, i.e., aging in growth and growth in aging. Growth is the main trend of literature information. A famous former Soviet intelligence expert, А.И.Михайлов, said that “At present, the growth of published articles, aging and discrete, is rightly deemed the most fundamental law of development of the scientific literature.”

The growth of scientific literature mainly refers to the number. The number increases with the growth of the number of times. In modern science development, the basic situation of literature growth performance for scientific literature is increasing at an annual rate of 6% to 8%. Approximately every 10 years, the number of scientific literature will be doubled. The literature published over the past

20 years is more than 2000. The time in which 1 million chemical abstracts (CAs) will be published in the United States is continuously shortening, i.e.,

First 1 million 32 years (1907–1938),

Second 1 million 18 years,

Third 1 million 8 years,

Fourth 1 million 4.75 years,

Fifth 1 million 3.3 years...

1 million at present, only 2 years.

Such information is a powerful indication of scientific literature surge. Scientific journals in the world comprise 100000 types, nearly 1 million types of books are circulated, and printed literature amounts to over 10 million in 1 year. This “information explosion” is a growing trend.

2.1.2 Influence of Literature Information Growth and Countermeasures

The rapid growth of scientific literature is an objective social phenomenon. The effects of and countermeasures for this phenomenon are important subjects to be explored.

(1) Surge of literature information

The rapid growth of scientific literature causes many problems and significantly influences the development of scientific research and literature collection, management, and utilization. The increasing scientific literature leads to overcrowded book libraries and intelligence agencies, accompanied by lack of funds and human resources. The collection and proper storage of such literature are difficult. Many intelligence service measures are also difficult to implement, thereby directly affecting intelligence efficiency and development. The working time of science and technology personnel is considerably increased. When they scan the literature, they are unable to check and read all the required information documents. A scientist can only read 5% of the professional literature. Literature quantity is significantly large, and thus, recall and precision of the required information are difficult for the personnel. The language barrier of reading literature is also increasing, thereby causing many difficulties in scientific research as well as extensive repetition and waste of scientific research. Experts estimate that nearly 40% of domestic research projects conducted by scientific research departments have foreign counterparts. This repetition does not only cause considerable waste, but also seriously affects scientific research efficiency and science development.

The corresponding loss is incalculable. A rough estimate made by a Soviet intelligence member indicated that if science and technology intelligence can be effectively used, then we will save 60% of the funding, on average, and shorten

research time for 2 years to 3 years. The considerable drop in “information explosion” intelligence literature utilization causes information loss by up to 20–80%.

(2) Countermeasures for literature information explosion

People apply basic countermeasures to adapt to the scientific literature information explosion situation via the following two aspects.

In theory, the growing number of scientific literature is the main cause of “information explosion” to strengthen the study of literature law. Therefore, actively implementing laws of growth and aging of the literature, which theoretically proves its inherent regularity, is one of the basic countermeasures to overcome the intelligence crisis. Research can be a reliable basis for the management and optimization of scientific literature and can guide the present stage of scientific literature, thereby making it more adaptable to the current literature surge. On the basis of new knowledge, countermeasures against literature growth have been proposed from the perspective of literature quality concept. For example, in the “International Federation of Literature, the 40th Annual Meeting” held in Copenhagen, Denmark in August 1980, American literature scientist H.R. Brinberg introduced the “more with less” intelligence collection principle, instead of the previous “the more the better” or 100% of the collection method. The proposal received the common response of the book intelligence community. Simon emphasized “content analysis” to establish related contact. Professional literature will not achieve unlimited expansion because of differentiation in subjects. Therefore, increasing the degree of specialization can reduce the burden that comes with literature growth to scientific and technical personnel.

With regard to technology, modern advanced technology and equipment, such as computer, are used to process and utilize document information. “As a result of the sharp increase in the scientific literature, library and intelligence agencies are facing great practical difficulties, and we should use machines to properly deal with the literature as soon as possible,” as stated by the founder of cybernetics, Wiener. Under this idea, the test and research for computer information retrieval began in the 1950s. Many countries in the world are presently using new highly efficient document-processing technologies, computer information retrieval systems, and information management integration systems, all working with automation. These advancements have all achieved evident effects. The specific measures include using new information carriers (magnetic tape, miniature flat piece, disks, and network), carrying out machine translation, setting up a computer literature information database, modifying online information retrieval, developing a network for literature information and knowledge, and establishing information and knowledge services.

The current situation requires China to take countermeasures. First, the formulation of long-term reasonable planning and development strategy, the creation of necessary conditions for forward modernization of intelligence, such as constructing and improving the literature intelligence agencies at all levels of various

types, and the establishment of a national intelligence network are crucial. Second, the retrieval procedure for domestic literature of science and technology systems should be improved as soon as possible, the law of document information should be explored extensively, and the information management of scientific and quantitative data should be accelerated. Finally, we should pay attention to taking practical measures to improve current intelligence work. A scientific quantitative method is used to select book journal literature; optimize collection; accelerate the construction, popularization, and application of characteristic database and information network; and provide readers with high-quality services.

2.1.3 Research on and Significance of Literature Information Growth Laws

(1) Significance of literature information growth rule research

The problem of scientific literature growth law has been a concern of the intelligence community for a long time and one of the main research subjects of metrology.

Research on the laws of scientific literature growth is of considerably important both in theory and in practice. The determination of the relationship between the sum of scientific literature changes and time can approximately present some characteristics and laws of science development. The intelligence model, which indicates the scientific prediction of a number of changes in accordance with the relevant literature, is widely used in intelligence analysis. We can also predict literature growth tendency based on the study of the rule of scientific literature growth, thereby providing a decision-making basis for the development of science and intelligence work in the future. Research on the rules of the growth of the scientific literature is not only an important theoretical problem of bibliometrics, but can also directly work for intelligence services, and therefore, help deal with the increasingly serious intelligence crisis. A Soviet intelligence expert, И.Б. Маршак, indicated that bibliometric research involves using information, including showing both the entire field of science with its individual inherent parameters and regularity. Such research is essential to optimize management when determining and implementing a research plan and is necessary in intelligence works.

(2) Status quo of literature information growth rule research

People have been exploring the law of scientific literature growth for a long time. As early as the beginning of the 20th century, several scholars began to study the total number of scientific literature. In the 1940s, the law of scientific literature growth attracted the attention of many researchers as a theoretical problem. Scholars have then made a series of research achievements in this field and

proposed various theoretical models to describe the law of literature growth. When D. Price introduced the rule of scientific literature exponential growth, a breakthrough has been made in this issue. Considerable statistical research and hundreds of papers are being circulated in Europe and the United States, and a number of monographs are being published in the science and information science fields in the Soviet Union. In China, the study of literature growth law remains limited and urgently requires strengthening. In a world scale, however, the problems in scientific literature growth regularity are among the most active subjects in the field of informetrics.

Research on the laws of relevant scientific literature growth mainly concentrates on two aspects. The first aspect is theoretical research, which focuses on establishing accurate mathematical models and theoretical explanations to further determine the growth regularity of scientific literature. The second aspect is using literature growth law to guide actual intelligence and information management and using a literature quantitative index to measure knowledge and present an application in the law of science development research. A famous intelligence figure, А.И.Михайлов, stated that a number of regulars had been gradually revealed, which marked the inner link between scientific publications and scientific development as well as the quantitative relationship in the number of articles published and the scientific growth index.

2.2 Growth of Science Knowledge and Scientific Literature

The growth of scientific knowledge is closely linked to the growth of scientific literature and its law. Therefore, when discussing scientific literature growth law, we should introduce scientific growth regularity of utility at the beginning. This introduction is necessary and helpful to fully understand literature growth law and mathematical models and correctly understand the law of literature growth theory.

2.2.1 Growth of Scientific Knowledge

After World War 2, science and technology have been rapidly developed and experienced a profound revolution. Science has developed into the “big science” era, namely, the period of modern science. The development of modern science is swift. One of the main performances is that the knowledge of human beings is rapidly increasing. Western countries show that human knowledge has quadrupled from the beginning of era of human being to the 1960s Table 2.1.

The double cycle of science learning becomes significantly shorter. The increasing and rapidly changing knowledge of humans has markedly expand

Table 2.1 Situation of increasing scientific knowledge

First double	Beginning of era–1750	1750 years
Second double	1750–1900	150 years
Third double	1900–1950	50 years
Fourth double	1950–1960	10 years

science at a rapid pace. Scientific results considerably influence the society and have exceeded the total results in the past 2000 years.

Over 100 years ago, Engels said that “the development of science is proportional to the legacy of utility that the previous generation leaves.” This view demonstrates the law of index development. Modern history also confirms that the numerous indicators in the field of science are according to the law of index growth. The mathematical language description is as follows:

$$W = \alpha e^{\beta t}, \tag{2.1}$$

where W is the scientific index, α and β are arbitrary constants, and t is time. Formula (2.1) is called the law of science and utility index growth. Some people also call it the law of science accelerating development.

The exponential law of science development was an important finding in the study of bibliometrics and science in the 1940s. The conclusion was based on the growth of SCI. D. Price researched and found the exponential growth trend of scientific journals. F. Ryder studied the growth of science books in the United States via statistics. In his book “the Science since Babylon,” he described the speed of scientific development and obtained the result that scientific development is increasing exponentially by considering science magazine and academic papers as important measures of utility.

The law of scientific development index growth has resulted in academic debates. One of the most important questions is that if the index of scientific indicators keeps increasing, then the number of scientists will be more than the total population of the world. In fact, this view is wrong because any scientific law is established approximatively under certain conditions. Exponential law is a law within a certain historical period. The “times” of scientific development are likely to be damaged at another time.

Figure 2.1 clearly shows that the rule of the scientific development index is broken twice in the special period since 1550; the first time was in 1670–1740, and the second started in 1940 and continues until today. Evidently, the index law was disrupted in a certain historical period but would be set up in another historical period

The index law is constantly set up and destroyed because the changes in the timeline are under the interaction of the accumulation model and specification for change. The former is characterized as the accumulation of utility, i.e., the so-called index development law. The latter is characterized by a qualitative leap, i.e., the so-called scientific revolution. The accumulation between normative and change is both opposing and unified. In the period during which standard accumulation

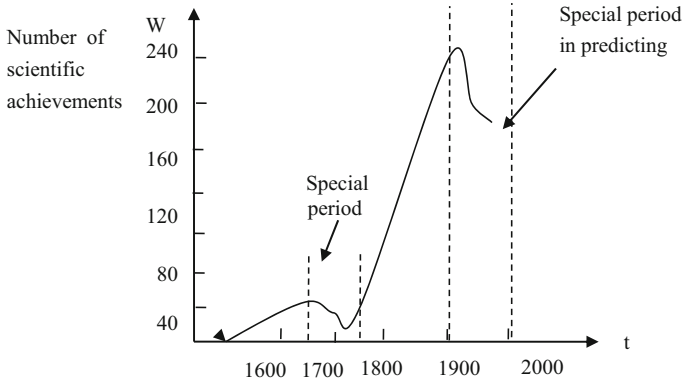
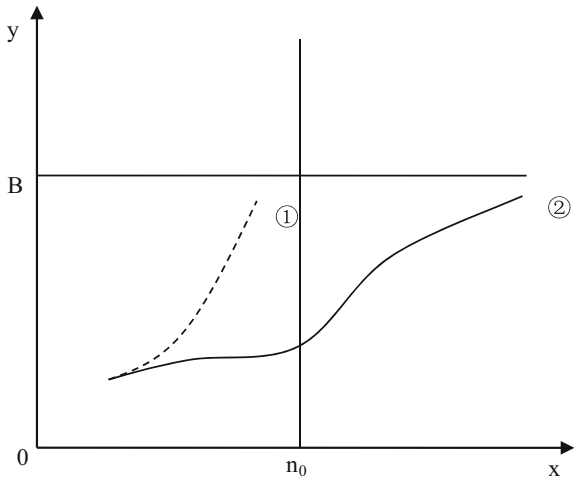


Fig. 2.1 Scientific development index curve

Fig. 2.2 Scientific development logic curve



works, scientific development follows the exponential law. When change specification works, the exponential law does not indicate anything. Consequently, the destruction of the exponential law is not a disastrous event, but one of the important signs of the arrival of the scientific revolution.

Another question about exponential law originates from the “saturation phenomenon” of scientific development, which is also called the “S”-shaped law of development. A few scholars abroad have held the point of view that any type of growth according to the index must balance at a certain point; otherwise, we will fall into fallacy. They have portrayed the entire history of science as a large “S” shape and supposed that index curve development would inevitably turn into a logical curve (Fig. 2.2). The contemporary period is on the balance point (point n),

and it will be close to the saturation limit in another 30 to 45 years Scientific growth is expected to stop by that time.

We believe that this statement is partial. The “S”-shaped phenomenon of scientific development is a historical fact, but is not always evident on the timeline. As shown in Fig. 2.1, the “S”-shaped phenomenon appeared at around 1670. Simultaneously, the index law occurred at “extraordinary times”. In the 18th century, scientific development presented a steeper index curve. In fact, the “saturation phenomenon” in science development is not surprising; this phenomenon is the nature of and a common regularity in human society. After a period of “saturation,” a new period characterized by the considerable acceleration of exponential growth will occur. The step exponential law undergoes “acceleration–saturation–broadening.” Science exhibits the relationship between growth of scientific knowledge and the growth of the scientific literature. The step exponential law does not only exhibit dialectical unification between quality and quantity in scientific development, but also suggest that the development of science and technology is endlessly advancing.

2.2.2 Relationship Between the Growth of Scientific Knowledge and the Growth of Scientific Literature

Scientific literature provides an objective record of scientific knowledge. The rapid development of science and technology will significantly increase scientific utility. All types of scientific knowledge should be recorded, preserved, and accelerated in the form of literature.

The number of scientific literature is one of the important measures of science and utility because changes in the number of scientific literature directly reflect scientific utility changes. As the main carrier of scientific information, changes in the number of scientific literature are also important symbols of science development. The number of science and technology books, academic publications about science, and scientific paper topics, such as the number of proportional literature volume, is frequently used as scientific indicators to reflect the scientific law of development in the study of science. The identification of various characteristics and laws of scientific development by analyzing the total number of relevant literature is the history of science, and scientific methods are frequently used in such study.

The growth trends of scientific literature and science knowledge are generally synchronous. Their growth rules also exhibit similarities to a considerable extent. Studies on the laws of scientific literature growth and science knowledge growth frequently cross and promote one another. The identification of scientific literature growth rules can provide the basis for scientific research on the laws of utility growth, which also helps deepen the understanding of literature growth rules. For example, D. Price proposed the theory that famous scientific knowledge grew

according to the index law of growth theory. One of the main bases of this theory is that scientific literature is based on the index law of growth. Thus, a close connection exists between the growth of scientific literature and that of science learning.

2.3 Exponential Law of Literature Information

2.3.1 *Indicators and Methods of Literature Information Measure*

The indicators and methods of literature information measure should be determined in literature quantitative research. Literature indicators can be classified into absolute value indicators and relative indicators. An absolute value index indicates the document number, such as the number of books, periodicals, and publications; a relative index indicates the proportion of different parts, such as the proportion of each type of literature and the proportion of each language literature.

Research on the laws of literature growth is generally based on literature accumulated data, especially in the research on the growth law of literature in a particular field or subject during a certain period, because the number of published literature and the cumulative number of literature always increase annually, which is likely a fixed rule. The results typically exhibit a rule curve, which can be described by an accurate function, and thus, are advantageous to the quantitative analysis of literature. The number of published literature each year is easily affected by various complicated social factors, and thus, is always fluctuating. Whether the number is similar to a set of rules is difficult to determine. The curve of the result has no rule and is difficult to describe in a certain function. All the aforementioned problems result in difficulties in the quantitative analysis of literature.

Two approaches can be adopted to measure the growth of scientific literature. The first approach is based on the total accumulated quantity of published literature each year, whereas the second approach is based on newly published literature quantity each year. The former focuses on utilizing the growth of the amount of literature, whereas the latter evaluates how much research literature is increased or decreased every year based on the number of new literature. Research on the rules of scientific literature growth is mostly from cumulative data but does not exclude the non-accumulated data of the research methods. The growth of scientific literature is shown by the increasing number of new scientific publications, and therefore, is typically measured by the number of published books each year. The growth curve generated using the measurement method can clearly reflect the change tendency of new literature every year. Although this irregular curve is difficult to describe using the quantitative description model in most cases, this approach is still frequently used to illustrate the problem in the study of intelligence analysis.

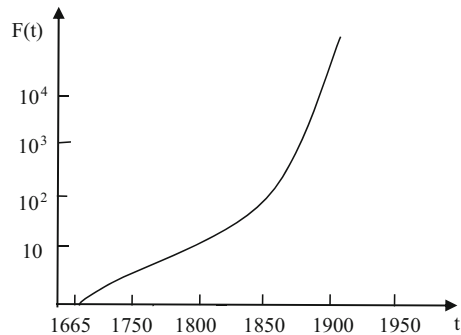
The results obtained using different methods and indicators to study the growth law of scientific literature vary. The examination of specific disciplines in the total number of journals published over a given period presents the law of exponential growth. However, as А.И.Михайлов indicated, “in judging the progress of scientific literature growth by the number of publications in each year, it is not even geometry but merely arithmetic.”

2.3.2 Literature Information Index Growth Model

As early as 1944, Fremont Ryder, a librarian at the Wesleyan University, studied the library collection rate of representative universities in the United States. He found that the main university library collection increased at the average of 16 years based on a huge amount of statistics. Thereafter, Derek de So11a Price, a famous scientist and intelligence expert, popularized and applied this discovery to all fields of scientific knowledge and conducted a series of research. In 1949, he found that stacks of philosophical transactions that stacked against the wall could become a perfect index curve. In the following year, he published the first research paper on exponential growth. In 1959, he presented a lecture series on scientific index growth at Yale University and officially published it in 1961 with the title “Science since Babylon.” In this classic scientific work, Price emphasized that the first scientific magazine in the world was “The Philosophical Transactions of the Royal Society of London,” which was published in 1665. Three or four similar magazines were then published by several European national academies of sciences. Science magazines published in 1700 were less than 10 worldwide. This number increased to 100 in 1800, 1000 in 1850, and 10000 in 1900. At present, scientific magazines in the world have over 100000 types. Accordingly, the number of science magazines has increased by 10 times every 50 years since 1750. Price also observed the same trend when he studied the growth of CA, biological abstracts, and science abstracts in recent decades. On the basis of these studies, Price identified the rule that science magazines increased exponentially. He obtained the same result when he statistically researched the characteristics of the increase in the number of journal articles using PA and 30 other abstracts. Price then concluded that literature in any normal growing field of science exponentially increased to double nearly every 10 or 15 years; the growth was approximately 5–7% a year.

Price’s comprehensive analysis of a large amount of statistical data considers the number of scientific literature as the longitudinal axis and historical s as the horizontal axis, thereby pointing out scientific literature in different s locations on the coordinate point by point, with each point connected by a smooth curve. This analysis approximately represents the rule of scientific literature growth over time and is known as the famous Price curve (Fig. 2.3).

Fig. 2.3 Exponential growth curve of scientific literature



Through the analysis of the curve, Price first observed the exponential function relationship between scientific literature growth and time. If the amount of literature at time t is expressed in $F(t)$, then the law of index can be represented as

$$F(t) = ae^{bt} (a > 0, b > 0), \quad (2.2)$$

where

- t time, in years;
- e natural logarithm of the bottom ($e = 2.718\dots$, can take approximately 3);
- b time constant, sustained growth, i.e., a cumulative increase in literature within a year and the ratio of the cumulative total last year

If r denotes the percentage of literature volume growth in one year, then $r = 100$ (eb) or approximately $r = 100$ b, $b = r\%$.

$$F(100) = 10,000e^{0.1(100)} = 220,264,660 \text{ (piece)}$$

At an initial moment, e.g., in a certain amount of scientific literature for $a = 10000$, the growth rate is 10%; 10 years later, the literature volume will be $F(10) = 10,000e^{0.1(10)} = 27183$;

100 years later, the amount of literature will be

$$F(100) = 10,000e^{0.1(100)} = 220,264,660.$$

The time d required for the literature to double is typically used as the quantitative indicator of literature growth evaluation. Formula (2.2) indicates that the formula for computing time is $d:n^2/b \ d = 1$. In the example, the time required for literature volume to double is $d = 6.93$ years.

Literature growth varies in different disciplines. The volume of some academic literature doubles every few years, whereas that of others requires over 10 years. For example, the multiplication period of chemical literature is 8 to 9 years. By contrast, the literature of certain areas and emerging cutting-edge disciplines, such

as atomic energy and environmental science, requires 2 to 3 years to double. The SCI growth rule is also relative to the cumulative number of annual literature.

2.3.3 Analysis of the Literature Index Growth Law

Correctness of the law of literature exponential growth

From a mathematical point of view, the price index growth formula, i.e., Formula (2.2), is an analytical function, and a derivative is obtained on the interval $(0, \infty)$. If the first derivative on $(2, 2)$ is taken, then we obtain the growth curve as

$$dF(t)/dt = abe^{bt} = bF(t). \quad (2.3)$$

The relative growth rate is

$$dF(t)/dt/F(t) = b. \quad (2.4)$$

Notably, $a > 0$, $b > 0$;

hence, $dF(t)/dt > 0$, $(0, \infty)$.

The mathematical point of view is as follows: exponential function $F(t) = ae^{bt}$ is a monotone increasing function on interval $(0, \infty)$. This function represents increases in scientific literature content over time.

Formulas (2.3 and 2.4) show that the growth rate of scientific literature is the index function that is decided only by the achieved level $F(t)$, and the relative growth rate is a constant. $F(t)$ represents the total number of literature in the past or in the near term, regardless of periodical publication, literature aging, and other factors. This conclusion agrees with the statistical results of the past history of literature.

From the point of view of statistics, the SCI growth rule correctly reflects the actual situation of literature growth. For example, a statistical analysis of the growth situation of world books in 1952–1982 shows that book types approximately double every 20 years. This analysis is a good fitting exponential growth model for the actual situation. Book growth in 1952–1982 conforms to the law of exponential growth. As Price emphasized, “the existence of the exponential curve is apparently universal and long term.” Therefore, the law of scientific literature exponential growth demonstrates a high degree of accuracy and is recognized by the public.

Limitations of the literature index growth law

The limitations of the literature index growth law are mainly manifested in the following two aspects.

Scientific literature does not always present exponential growth. A relationship exists between Price’s index growth model and research literature in terms of discipline and time. Numerous studies have shown that extensive research subjects require a long time to follow the index law. The counting of beginning time significantly influences literature growth. The growth obtained from statistics is

larger than the actual growth rate. Thus, not all subjects in any period of literature increase as an exponential growth pattern. In fact, a flat trend of exponential growth curve in literature steepness occurs.

The index law cannot predict the future trend of literature growth. We attempt to investigate curve (2, 3) to determine what causes the laws of scientific literature absolute growth to change over time as follows:

$$\begin{aligned}\Delta F(t) &= ae^{b(t+1)} - ae^{bt} \\ &= a(e^b - 1)e^{bt}.\end{aligned}$$

When $t \rightarrow \infty$, $\Delta F(t) \rightarrow \infty$.

As time passes by, the increment in scientific literature tends toward infinity. This finding is evidently unrealistic. Thus, based on trend extrapolation in the research field of prediction, the Price curve is used to predict the amount of scientific literature at a certain point in the future. When the forecast period is longer than 10 years, reliable results are difficult to obtain. Although many factors influence literature growth, such growth is mainly the result of scientific research and the growth of scientific and technological personnel. If scientific literature has always been in accordance with exponential growth, then even if every person in the world becomes scientific research personnel and scientific research funds account for 100% of the national output, the requirements for scientific literature infinite growth will remain difficult to fulfill. The scientific literature law of exponential growth has exhibited the limitation that it cannot predict future scientific literature trend. Reason for the limitations in the literature exponential growth law.

In summary, the law of science literature index growth correctly reflects the growth situation of scientific literature in the past but cannot predict the future scientific literature trend.

The growth of scientific literature is a complicated social phenomenon and process. The limitations of the literature index growth law are attributed to the influences of many complex factors on the growth of scientific literature and restrictions, as specified below.

Theoretical research on scientific literature growth remains limited. Various factors that influence literature growth are difficult to fully consider and provide an accurate analysis and quantitative description.

In establishing the exponential growth regularity of scientific literature, Price did not consider the increasing aging of literature.

When Price accumulated the total number of scientific journals in one year, he did not rule out unprinted journals. A. I. Miharove highlighted that every three types of science and technology journals appear while journal closure occurs. The influence of this continuous publication closure should not be ignored. Therefore, the price index growth model has certain errors.

2.4 Law of Literature Information Logic Growth

2.4.1 Literature Information Logic Growth Model

On the basis of research on the SCI growth law, scholars from many countries have conducted considerable research and have proposed several theories and mathematical models to search for a perfect literature growth model. This research trend has created the largest effect of “literature information logistic growth model.”

In 1963, Price discussed the scientific literature exponential growth law and the logic growth law for scientific research personnel in his classic book “Little Science, Big Science.” He argued that exponential law would eventually become a logical type.

В.Налимов, a scientist from the former Soviet Union, researched the scientific literature growth law and found that literature growth comprised stages, with each stage having a different growth model. For example, the use of the exponential model to describe the literature in the field of system research in the Soviet Union between 1957 and 1974 can be divided into three periods. The doubling time of each period literature differs.

After extensive research, В.Налимов and Г.ВлЭдудц determined that scientific literature initially passed through a rapid growth process and then gradually slowed down. The growth process of the growth rate index changed into a logical curve growth process. Налимов and ВлЭдудц also considered that material conditions, economic sources, and author intelligence influenced the growth rate of scientific literature. On the basis of a specific literature research, they proposed the famous literature logical curve theory and model as follows:

$$F(t) = k/(1 + ae^{-kbt}) \quad (b > 0); \quad (2.5)$$

$F(t)$ literature cumulant during t years;

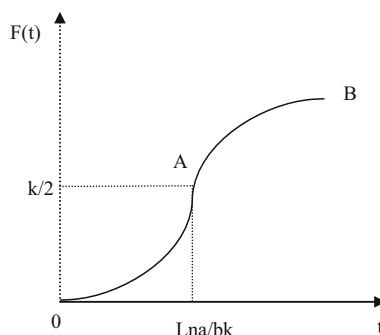
k literature cumulant, $t \rightarrow \infty$ is the maximum literature cumulant;

a, b parameter

If the second derivative is taken with Formula (2.5) on t and the second derivative is zero, then the inflexion point A of curve (2.5) can be obtained for the coordinates $(\ln a/kb, k/2)$. This curve is symmetrical around the inflection point and is called the logic symmetry curve.

Figure 2.4 shows that literature growth will be limited ($y < k$). The relative growth rate $(\frac{dy}{dt})/y = b(k - y)$ is a linear function of y . When $t < \ln a/kb$, the growth rate is increasing; when $t > \ln a/kb$, the growth rate is decreasing. The growth rate evidently slows down when y is nearly approaching k . The aforementioned process respectively corresponds to the curves of OA and AB .

Fig. 2.4 Scientific literature logic growth curve



When $y < k$, an approximate growth curve can be obtained from (2, 5), i.e., $dy/dt = kby$; the relative growth rate of the curve is $(dy/dt)/y = kb = \text{constant}$. The initial stages of scientific literature growth are in accordance with the law of exponential growth. However, the index value changes with the change in time t , and relative speed is not always the same. Consequently, the exponential growth momentum cannot be maintained. When literature volume increases to half of the maximum, its growth rate becomes small and tends toward a limited value of $y = k$.

The logic curve of scientific literature is relative to the accumulation of the present number, which is a conclusion obtained based on statistics and research in a certain field of knowledge or the same type of literature for a long period.

2.4.2 Analysis of the Law of Literature Information Logic Growth

(1) Correctness of the law of literature information logic growth

Friedrich von Engels indicated that the movement of the universe was confined within a limited circle of infinite development in the book "Dialectics of Nature." The logic rule of scientific development is similar to this thought. This finding shows that science is experiencing a process of time continuation. This process is a prophase slow development in the early stage, acceleration development in the middle stage, and speed reduction until the late saturated development. Saturated development does not indicate the end of science development, but instead, it denotes that science development has achieved a dynamic and balanced system. The science development process corresponds to the logic growth process of scientific literature. Therefore, the literature logic growth rule exhibits considerable necessity and rationality in terms of philosophy or science.

In fact, the scientific literature growth logic curve has succeeded in describing the literature growth rule. The logic curve perfectly describes the growth law in terms of the growth of the scientific literature for a specific subject area. The growth

of the literature on coal gasification counted by D.J. Frame et al. from 1965 to 1975 perfectly conformed to the logical growth curve model. Several stages of the literature development on mast cells have compellingly proven the correctness of the logic curve growth rule.

From the perspective of scientific history, all the subjects in the field of science are currently in the birth, development, and relatively mature historical stages. Statistics show that when subjects are in the birth and development stages, scientific literature exhibits exponential growth. However, the lifespan of scientific literature is relatively short. The growth rate is inversely proportional to the lifespan of literature. With the deepening of subject research and coming into a relatively mature period, the growth of scientific literature cannot maintain the original index rate, the growth rate decreases, and the curve flattens out. Thus, the lifespan of literature becomes relatively longer. However, the decrease in literature growth rate does not indicate a stagnation in scientific development. This scenario is still considered a relatively mature stage after major research progress has been made in a particular knowledge field. It can also imply that knowledge areas are facing a new breakthrough and will produce updated subfields.

The descriptions of the constants (i.e., a , b , and k) in the literature growth logic curve of different disciplines generally differ. If we can separately perform a comprehensive statistical analysis of the literature growth of each specific discipline and draw a logic growth curve, then these approaches can play a certain practical guiding role on stage evaluation, future development prediction, related literature collection, and intelligence service. Therefore, research on the law of scientific literature logic growth considers the theory of information science, has scientific value, and can serve as a guide in practical applications.

(2) Limitations of the literature information logic growth law

Scientific literature logic growth theory, which is relative to Price's growth theory, is a significant improvement. Logic curves can be utilized to describe the growth of past literature and predict future literature growth. However, several literature statistical studies have not reached a logical conclusion, such as the curve. The logic curve has limitations, i.e., as indicated in Formula (2.5), when $t \rightarrow \infty$, $y \rightarrow k$, $dy/dt = by(k-y) \rightarrow 0$. This scenario shows that when the scientific development is at a certain stage, the growth rate of scientific literature tends to be zero, and the amount of insurmountable scientific literature reaches its maximum value. This scenario further implies that after a certain stage wherein no new scientific literature is developed, scientific literature will fade away from the field of human science communication as a means of transferring information. Therefore, some scholars believe that the development of science will reach its limit someday and then will be eventually saturated. Scientific progress will become stagnant or even suffocate. Price asked questions regarding this issue in his book "Little Science, Big Science," which was also at the extreme side. The quantity growth of literature on science and technology is slowing down, but this situation does not imply that the speed of scientific development will drop. In addition to scientific literature that reflects

human awareness, knowledge, and support level in the form of the further development of scientific research, we can have new and better communication technology intelligence methods. This scenario makes it possible for us to supplement or gradually replace existing traditional forms of scientific literature.

(3) Reason for the limitations of literature logical growth

The difficulties in utilizing exponential and logistic curves (i.e., semi-exponential curve) to predict the future amount of scientific literature has two main reasons. First, an exponential growth model has several limitations as previously mentioned. Second, the predicted scientific literature on these two growth curves is developed based on the predictions of trend extrapolation. However, scientific literature is a complex system of scientific communication subsystems, and its growth is affected by many aspects of laws and constraints. The adoption of system theory to its systematic analysis can obtain more accurate results. This approach should be the starting point of our modified index and logistic curves to explore a new scientific literature growth model.

2.4.3 Modification of the Model for Literature Information Logical Growth

The logic of the scientific literature growth curve overcomes the defects of index curve “divergence”, but the limitations of “bounded of the index curve” remain, which must be further improved. The modified literature in the logistic growth model must fully consider the influence of different factors, which is the correct thinking approach.

First, the basic processes of growth, mechanism, and trend in scientific literature must be clarified. The growth of scientific literature will generally experience two large transformations in the past and future of a long historical period. The first transformation is from exponential growth to a logical type of growth, and the second is from logical to linear growth. The transformation can either be gradual or sudden. Science will have different means and tools for communication with the development of science and technology, but scientific literature can remain as a means of communication for a long period. A particular balance can also be achieved. That is, the absolute growth of literature each year will experience ups and downs, but deriving the statistical average for the long term shows that the annual growth in literature is the same. The amount of scientific literature basically increases with uniform velocity at any time.

Second, scientific literature must be regarded as a communication system in its entirety in studies. A scientific literature system is a subsystem of scientific information communication. An information exchange system of the interaction between

each subsystem is generally nonlinear, and the scientific literature growth model is a solution set for nonlinear and complicated partial differential equations.

Furthermore, we must identify the main decisive factor and disregard other relatively minor factors. The rapid growth of research, science, and technology personnel is evidently a factor that affects scientific literature development in two of the most powerful sectors.

Finally, we must determine the specific goals and requirements of a model. New mathematical models must overcome index curve “divergence” and the “limited” logic curve of difficulty, as well as describe a better approximation of the literature growth rule. When $t \rightarrow \infty$, the growth rate of scientific literature dy/dt is a constant, which is unlike the logic curve that tends toward zero. Literature also does not tend to be a maximum total k , but acts as a function of time. The annual growth in scientific literature also tends to be stable when $t \rightarrow \infty$, which suggests that scientific literature exists simultaneously with other scientific communication media. The scientific communication system forms a relatively stable “ecological balance” with the social, economic, and technological development levels. This scenario is in line with the actual process and development trend in scientific literature, which can provide a relatively satisfactory explanation for the literature growth rule.

From the preceding principle, a new and more appropriate description for the literature growth regularity of a mathematical model can be constructed based on the logic curve, thereby increasing secondary modifications and considering a constant term after reasoning and transformation.

2.5 Other Mathematical Models for Literature Information Growth

2.5.1 Linear Growth Model

(1) Contents

Linear growth of scientific literature:

$$F(t) = bt + a \quad (2.6)$$

where

$F(t)$ t : amount of literature growth per year,

b literature growth gate,

a amount of literature when $t = 0$

(2) Analysis

In 1963, Price indicated that the index law could likely be damaged, and the literature of exponential growth could not continue forever. In fact, some aspects in literature do not regard the growth model for the exponential curve as a logical curve. However, they also present a linear growth model as stated in “Little Science, Big Science”. A.I. Mikhaylov stated that the members of the Eastern Europe Cooperative Organization within the scope of science books and journals, as well as the number of patent specifications, all exhibited a straight line law of growth. Relevant statistics show that several books and pamphlets published worldwide from 1960 to 1972 also exhibit a linear law of growth.

The scientific literature linear growth model does not only apply to describing certain knowledge or types of literature growth. The development of science and literature in the future will be more inclined toward the linear model. Rescher indicated that linear growth would be attained in the future through past exponential growth.

2.5.2 Hierarchical Sliding Exponential Model

(1) Contents

Nicholas Rescher, an American scientific historian and information scientist, believed that the world could not bear the input index of literature, and publication growth would become linear during the years when resources were lower. In his book “Scientific Progress,” Rescher indicated that the growth rates of publications with various quality levels differed with the increase in publication number related to their quality. Hence, the following hierarchical sliding exponential model was proposed to describe the scientific literature growth rule.

Rescher introduced the index λ , which represented the quality of literature, and $0 < \lambda < 1$. The meaning of λ is detailed as follows:

$\lambda = 1$: common literature (i.e., it represents all literature types),

$\lambda = 3/4$: literature with meanings,

$\lambda = 1/2$: important literature,

$\lambda = 1/4$: highly important literature,

$\lambda = 0$: most important literature.

The number of literature and literature features vary in different quality levels. In particular, if the amount of literature is $F(t)$ at time t , then the number becomes $[F(t)]^\lambda$ at the λ level. The λ equations are presented as follows:

$$\begin{aligned}
F(t)_{\lambda=1} &= ae^{bt}, \\
F(t)_{\lambda=3/4} &= (ae^{bt})^{3/4}, \\
F(t)_{\lambda=1/2} &= (ae^{bt})^{1/2}, \\
F(t)_{\lambda=1/4} &= (ae^{bt})^{1/4}, \\
F(t)_{\lambda=0} &= 1 na + bt.
\end{aligned} \tag{2.7}$$

$$\tag{2.8}$$

For example, in the case of a million literature samples, the number of literature in each level is as follows based on the preceding equations:

$$\begin{aligned}
\lambda &= 1:1,000,000; \\
\lambda &= 3/4:31,623; \\
\lambda &= 1/2:1000; \\
\lambda &= 1/4:32; \\
\lambda &= 0:14.
\end{aligned}$$

Hence, the following conditions can be shown.

- ① The first level ($\lambda = 0$), or the number of most important literature, is extremely few, which occurs only as 0.0014% of the total.
- ② The number of important literature ($\lambda = 1/2$) is the square root of the total number.
- ③ When $0 < \lambda < 1$, the number of literature is still increasing at all levels based on the index law only when people attempt to improve their quality. Growth speed gradually slows down with the increase in literature importance degree. When $\lambda = 0$, the rules are completely broken. Only a constant increase during each period is observed. Thus, the number of literature at that time will increase linearly.

At time t , the number of primary literature is $F(t)_{\lambda=0} = \ln F(t) = \ln ae^{bt} = \ln a + bt$. When the annual growth rate is assumed as 10%, important documents increase every 10 years. Such growth speed is relatively slow.

In this model, if the double time of total number of documents is d , then the quality of the λ level for the λ literature doubles the amount of time decided by the press type as follows:

$$d' = 1n2/b\lambda = d/\lambda. \tag{2.9}$$

For example, the literature volume doubling time is 6.93 years in the third quarter, and thus, the time that corresponds to each λ level literature volume doubled (d) is as follows:

$\lambda = 1:6.93$ years,

$\lambda = 3/4:9.84$ years,

$\lambda = 1/2:13.86$ years,

$\lambda = 1/4:27.72$ years,

$\lambda = 0:10$ years to increase the λ primary literature.

This scenario shows that the growth speeds of different literature quality levels differ. Scholars call this phenomenon the “principle of quality check,” wherein literature growth is affected by quality.

(2) Analysis of the slide grading index model

The le hill model shows that the growth rates of different literature quality levels vary. The more important the literature type is, the slower its growth rate. A few high-quality papers are always accompanied by many general papers, which is a logical condition. The le hill model can also be considered an attempt to study the growth rule from the internal process of growth in scientific literature. However, using specific data to verify the correctness of the model is difficult. For example, Kenneth Mei considered the new ideas and results of his thesis as the first level of the first important documents. Mei identified the determinant and conducted a statistical analysis on the aspects of a paper before 1923 according to six types. However, his results cannot prove that the le hill model is correct.

2.5.3 *Transcendental Function Model*

Former Soviet Union intelligence scientists Р.А. Гиляревский and Шремдер stated that scattered journal articles must be considered factors of the increase in scientific journal articles. When obtaining a journal rank in a discipline or knowledge field according to Bradford’s distribution, the growth in periodical publications varies at different grades. Thus, these scientists proposed a new model that highlighted growth in number, called the transcendental equation or Ji growth model.

This model also attempts to delve into the internal structure of literature growth to determine the different distributions of the literature growth law. However, this model is only a special hypothesis theory model that studies the increase in number of journal articles.

2.5.4 Шестопа́л–Бу́рман *Growth Model*

(1) Content of the Шестопа́л–Бу́рман growth model

The growth in scientific literature is a significantly complicated process. Not only the absolute number of new literature differs every year, but the relative growth rate also varies. Price, Rescher, and other researchers had long believed that the increase in literature should be less increasing". In particular, the relative growth rate increases with the increase in time t , which then decreases with increasing total N or literature. Soviet intelligence experts В.М. Шестопа́л and П.Н. Бу́рман proposed a new type of literature growth model in 1978 from the perspective of research in the quantitative evaluation of document information flow growth.

For a convenient discussion, the literature growth equation is first rewritten in the following form:

$$dN/dt = qN \quad (q > 0), \quad (2.10)$$

where

N total number of literature accumulated;

q relative growth rate, which can be represented by t as $q(t)$. Thus,

$$dN/dt = q(t)N.$$

Furthermore,

$$N = N_0 \bullet e^{\int q(t)dt}$$

or

$$\ln N = \ln N_0 + \int q(t)dt. \quad (2.11)$$

This equation represents the research literature information flow growth model.

(2) Analysis of the Шестопа́л–Бу́рман growth model

The Шестопа́л–Бу́рман growth model from the literature growth rate q is a variable set used to study the growth law of literature. This model is a significant correction of past research. Formula (2.11) includes the literature index growth model, as well as the linear growth model and the index of the sliding model. Therefore, the proposed model is a significant progress of the science literature growth rule. Models cannot applicate but give up, including the logical growth curve model and the general model. Formula (2.11) is clearly not comprehensive.

Шестопал and other researchers used the direct graphic model, whose methods could be applied to determine the expression of q . This approach results in a larger error, and thus, applying the least squares method is better.

2.6 Analysis of the Mechanism of Literature Information Growth

We have discussed the six models for describing science literature growth laws in the previous sections. Some of the increases in scientific literature follow the exponential rule, which is a complicated process. Some exhibit regularity with a logistic curve, whereas others are linear. Different models indicate a common point, i.e., science literature increases with time, and the only difference is the velocity of increase. This section discusses the mechanism of science literature growth, which explains why the number of science literature increases and why the increase follows different models.

2.6.1 Reason for Literature Information Growth

Scientific literature growth occurs for many reasons. The basic reason is the rapid development of science and technology, which has also significantly boosted its disciplines, research groups, and funding. Therefore, scientific research is continuously generating new discoveries that can result in the continual expansion of science literature. The progress of science and technology can lead to an increase in the number of publications, which is a common occurrence. For example, the emergence of new technologies in laser and variety improvements has resulted in a surge in literature, from approximately 20 papers in 1960 to 1200 papers in 1965. In particular, the main reasons for the increase in science literature are discussed as follows.

(1) Surge in research finance and number of researchers

Scientific development is a basic indicator of the numbers of scientific research, scientific and technological personnel, and science and technology literature. The increase in the third aspect is largely the result of the increase in the first two aspects. Price's theory states that the exponential input of the entire science system (i.e., finance, human resources, and material resources) has led to the exponential output of science literature. The main reason for the rapid increase in science literature is that research financing and number of researchers are also rapidly increasing. The increase in scientific research investment and number of researchers will undoubtedly lead to an increase in scientific research achievements, as well as record and reflect the increasing number of scientific results. World research financing doubled every year from the 1900s to the 1970s. The number of

researchers increases tenfold every 50 years. For example, 1000 researchers were documented in 1800. The number increased to 10000 in 1850, 100000 in 1900, 1 million in 1950, and 10 million in 2000. These increases are attributed to the increased funding and the increased number of scientific research personnel, which have doubled scientific literature every 15 years.

Research financing and number of researchers have been increasing exponentially; however, the orders of these exponents exhibit differences. In 1966, Price determined the relationship between these three factors, i.e., the growth of the cost of scientific research is squarely proportional to the number of researchers. Nevertheless, the number of scientific products only increases proportionally with the square root of the number of researchers. When the number of scientists is n , their financing is n^2 , but the number of scientific literature is $\sqrt{n}$. For example, when the number of scientists increases thrice, then research financing will increase 9 times, whereas the number of literature will increase 1.7 times. This conclusion can approximately demonstrate the relationship among science literature, research financing, and number of researchers (Tables 2.2, 2.3 and 2.4).

(2) Expansion and detailing of the professional scope

Over 2300 disciplines currently exist worldwide, and 10 billion publications have been documented as of 2005.

(3) Mutual infiltration among disciplines

No closed discipline exists in modern science, such that innovations and inventions can affect other disciplines, research methods, or can directly be applied to other disciplines.

(4) Internationalization of science and technology

Important inventions or discoveries can more easily become worldwide trends and will be immediately available for further study. Thus, people must collect all of the literature and information in the world for transfer and utilization.

(5) Cooperative and collective research

At present, hundreds and thousands of people are being mobilized, and billions of research projects are still increasing. The multinational cooperation development project that focuses on the continual research of cooperative and collectivization degrees is strengthened.

Table 2.2 Increase in scientific research personnel worldwide

Time	Number of scientists
1800	1000
1850	10 000
1900	100 000
1950	1 000 000
1970	3 200 000
2010	11 260 000

Table 2.3 Funding growth in the United States

Year	1920	1930	1940	1950	1955
Project					
Cost (millions of US dollars)	80	160	377	2870	6270
GDP ratio (%)	0.1	0.2	0.4	1.0	1.6
Year	1960	1965	1970	1975(estimation)	
Project					
Cost (millions of US dollars)	13 730	20 430	26 566	35 600	
GDP ratio (%)	2.7	3.0	2.7		

Table 2.4 Funding growth in the Soviet Union

Year	1950	1955	1960	1965	1970	1971	1972
Project							
Cost (1 billion rubles)	1.0	-	3.9	6.9	11.7	13.0	14.4
GDP ratio (%)	1.8	-	2.7	3.56	4.03	4.27	4.60
Year	1973	1974	1975	1976	1977	1978	
Project							
Cost (1 billion rubles)	15.7	16.5	17.5	17.7	18.2	19.1	
GDP ratio (%)	4.65	4.67	-	4.0	-	-	

(6) Shortened research cycle and boost in production and translation

Statistics showed that the commercialization cycle of inventions before World War 2 was 20 to 30 years, which had been shortened since then to only 2 to 3 years, and eventually to 1 over 10 years.

(7) Improvement in communication, publishing technologies, and information science

With the development of science and technology, as well as more advanced communication, literature databases, online services, and ongoing research project information science are expanding. All of the aforementioned factors have accelerated the exchange in scientific literature and have promoted the rapid increase in scientific literature volume.

Scientific literature is comprised of the requirements of society and the growth of a country's policies on the development of scientific and cultural undertakings.

2.6.2 Explanation for the Literature Information Growth Law

We considered that the laws on the increase in the number of scientific literature are determined by the objective process of scientific development. The actual process of scientific development is restricted by two factors: the intrinsic of science law and the environments of science.

- (1) Scientific development laws influence on the increase in literature information laws

The science discipline teaches that the changes in number of scientific literature denote an important symbol of the development of science itself. Thus, we developed our model to explain the growth of scientific literature analysis according to scientific development.

The famous science historian and scholar Thomas S. Kuhn proposed the science development pattern in his book "The Structure of Scientific Revolutions." Kuhn believed that scientific revolution would always occurs, and that its development process would occur from "original science" to "normal science" and the transition from "normal science" to another "normal science" of the process. Entire processes of scientific development are repeated in cycles under the impetus of scientific revolution.

During the original science period, many scientists from different academic schools were writing articles to participate in scientific discussions, thereby increasing the number of schools of thought. Although the amount of scientific literature was not large at that time, it was still increasing rapidly. Its growth rate was akin to a constant, and scientific literature followed an index law of growth during this period. New ideas and achievements of the most important papers of the period were recorded.

When normal science occurred, general science was in a mature and stable development period. New ideas and achievements were widely adopted in education, popularized, and promoted during this period. Hence, the number of science literature and its incensement were large, but the increase rate had declined. The total number of literature would become an extremum. The growth in literature transformed from the exponent model into the logical curve model. The increase in logic curve tended toward the extremum, which showed that the discipline or knowledge area was developing into a new crisis after long-term stable development. When a crisis occurred, the scope of the subjects would be changed or divided to produce new disciplines. Science literature would transition once more to an exponentially increasing stage along with science revolution. Therefore, if the statistics of the literature for a fixed number of years corresponded to a knowledge area from original science to conventional science or from conventional science to update the entire period of normal science, then the logical growth curve model would be followed.

Kuhn's theory of scientific revolution states that the logistic growth model should be the ideal model of the scientific literature growth law. Logic curves with exponential curves are similar to the former period and near the inflection point at an appropriate time interval that can be approximately regarded as a straight line. If the statistics of the fixed number of years roughly correspond to any of the aforementioned scenarios, then the three periods can be obtained through a linear growth model. Numerous science disciplines at present have transitioned into normal science from original science. The literature in many knowledge domains tends to increase linearly in this scenario.

Menard's research shows that a discipline in the general literature growth rate changes according to three different periods as follows:

- ① Stable stage—increasing in line, science was at its birth;
- ② Increasing stage—increasing rapidly at an exponential rate, science was developing;
- ③ Cycle stage—stability and growth occur alternately, science had matured.

Rescher believed that the scientific development process was not a process of addition but a process of subtraction. The main findings at present are the opposite of past conclusions because information absorption is accorded with the "effect of decreasing return of law" and literature growth from the perspective of economic analysis. The development of disciplines and shifting of scientists interested in paper distribution do not only exhibit an exponential growth state, but are also conditioned by many factors and have many distribution states. Therefore, the number of literature is increasing following different growth models.

(2) Social environment influences the literature information growth rule

Scientific environment conditions, including politics, economy, culture, education, and other social conditions, clearly affect the number of science literature laws. These conditions determine the quantity and quality of scientific research investment and scientific research personnel. Thus, they also determine the number of scientific research achievements and approximately reflect the results of the number of scientific literature. The community requirements and provisions for financial, human, and material resources frequently determine the emergence and development of a science field. Scientific literature is not only required by the law of scientific development, which is a theoretical growth model in itself, but also by different social and environmental conditions of restriction. For example, the First and Second World Wars, and the damages inflicted by these wars on the development of science and technology, resulted in two "trough" periods. Scientific literature also underwent two major declines, which caused the pattern of certain disciplines to change from an exponential growth curve to a logical one. Given the current shortage in resources, the society has been unable to develop a scientific system that provides an index input. The exponential growth in the 1970s resulted in mostly linear publications, coupled with an amount that corresponded to the general scientific literature growing characteristics. This scenario caused most of

the scientific literature to transition from exponential to linear growth from the past to the future. Socio-environmental conditions frequently cause an increase in scientific literature, which exhibits random process characteristics and changing growth rate. Carrier technology, increase in scientific literature publishing technology, effects of computers and modern communication technology, and many other factors can also be considered random processes.

2.7 Applications of Literature Information Growth Laws

Research on scientific literature growth laws plays an important role in science history, science, and theoretical and practical information science. Their applications mainly include the following aspects.

2.7.1 Applications to Science of Science

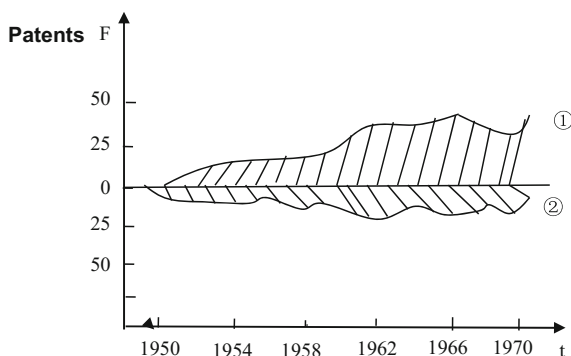
The increase in the number of documents changes the rules for judging and predicting the growth of scientific knowledge. It then explores the law of development of science as a whole, which is a commonly applied method in the history of science and scientific research. In this case, G. Gilbert proposed that establishing the following hypothesis would be necessary before working on studies: all knowledge should be contained in published literature, and each document should contain the same amount of knowledge. A. Doyle provided a more vivid metaphor: "Like saving money to provide the interest, knowledge generates new knowledge that in the increases in knowledge is just as banks offering compound interests—Growth in any time will produce a fixed percentage of the number of recent."

In a large-scale study of science and technology, the increasing number of scientific literature laws generally simulates the development process of science and technology, as well as explores its laws. The price of conclusions on the exponential growth law of science and technology indicates scientific literature quantities according to the index law, which is from the growth based on a conclusion. Therefore, the laws of scientific literature research are efficient paths in the study of science history and theory applications.

2.7.2 Applications to Information Research

From the perspective of information science, studies on the increasing law of science literature is a reliable method for scholars in information science research,

Fig. 2.5 Patent distribution of semiconductor diffusion technology in the world ① and ② curves indicate the number of changes in relevant patents in Japan and other countries in the world, respectively (1949–1970)



allowing them to understand the trend of science development, and to make scientific predictions.

The increase in the number of scientific literature can denote a country with a technological development process and achievement levels. In all literature types, patent documents are the most sensitive indicators of science and technology development. Hence, scholars frequently utilize the change in the number of patent documents in intelligence analysis. Figure 2.5 shows the changing curve of the relationship between the number of patents for Japanese semiconductor diffusion techniques and the number of patents from other countries from 1949 to 1970. From the perspective of science, studies on the growth laws of science literature are reliable methods for scientific researchers to analyze information science, as well as to understand the trend of science development and scientific predictions. Japan started this research trend two years later than other countries. It then caught up with other countries in 1964, and eventually became the leader in 1968. The need for technology import provides a reliable decision basis for the current study. Therefore, changing the number of literature can fully comprehend a branch or technical area of the entire formation process, development, and future trend; select a scientific research topic; and identify a technical solution to provide a quantitative basis.

2.7.3 Application to Literature Information Management

Research on growth laws began with studies on library management. Libraries or intelligence agencies determine reasonable allocation of funds, principle of data collection, collection increase strategy, storage space expansion measures, information processing, and transmission of exchanges in new technology applications. These processes are contained in the number of scientific literature, which is an important decision basis of future growth trends. For example, a literature center

can be increased by studying its collection of laws and trends, as well as by determining the budget and size of collection development. The detailed decision must add the number of shelves and area of library expansion.

However, several factors and problems, such as research tools, mathematical models, research methods, and reliability of results, still affect these studies.

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