Solving Problem of Multi-Link Rate in the Economic Field with the Idea of Chemical Kinetics and Complex Reaction Treatment

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Abstract. The problem of multi-link income in economics is very similar to the multi-link reaction in chemical reactions. Take several companies as an example, this paper simulates the rate of return by chemical kinetics, and compares it with the actual data, and the results are universal. By analogy, the method can approximate the data of the rate of return of a certain link, or estimate the overall rate of return of the system through the data of the rate of return of multiple links.

1. Introduction

For complex reactions in chemistry, we treat them as additives of several elementary reactions. For each elementary reaction, it may also be multi process. These include parallel reactions, standoff reactions and continuous reactions. By splitting a set of complex reactions, we can split them into multiple distribution reactions. The approximate reaction rate is approximated by the quasi steady state method and quasi equilibrium method. This approximation method has been used in chemical industry for nearly a hundred years. In the economic field, the issue of revenue from multiple links is very similar to complex chemical reactions. For a huge system, the system can be split into import links, production links, and logistics and so on. And every major link can be broken down into several basic links. Each basic link can be derived from a relatively simple mathematical formula. As a whole, it is a critical reaction to determine the rate of revenue of the whole system, and the income expenditure of certain part of the whole system remains relatively stable with time, so this series of links can be analogous to the formula of complex kinetics of chemical dynamics.

2. Present research situation

In modern business, the most important steps that affect final earnings are often determined by the initial condition and the slowest step in the process. This corresponds to the quasi steady state method and the quasi equilibrium method respectively in chemical kinetics. Xu Zheng Jiu [1] studied the treatment of chemical kinetic homeostasis in 1987; Liu Zhiyong [2] studied the estimation of parameters in chemical kinetics in 1992; Qian Weiqi [3] simplified chemical kinetic model in 2004;Lu Xin sheng [4] in 2010 simplified the calculation method of chemical kinetics; in economics, Zhou Sanyuan [5] in 2012 get a preliminary conclusion drawn on the use of chemical kinetics in product recovery; Zhao Na [6] use the quasi equilibrium method in 2013 to study the changes in the price of mutton from the farmers to the market; Li Haopu [7] proved that the economy was influenced by many factors in 2015. To sum up, we can use chemical kinetics to study the problem of multi-link income in the economic field.

3. Ideas on the treatment of complex reaction in chemical kinetics

The rate of chemical reaction is the derivative of reaction time and concentration at any time. For a macroscopic reaction studied, the reaction can be decomposed into a basic reaction step by step. The elementary reaction is a direct reaction of reactant molecules to produce new products.

The rate of elementary reaction is directly proportional to the product of the power of each reactant, and the sum of the powers contributed by each reactant is the series of reactions. In addition to the simple reaction of A to B, there are three complex reactions: parallel reaction, continuous reaction and confrontation reaction. From the macro point of view, a reaction can be solved in two ways. The first idea is a quasi-steady state method, which means that the concentration of the active reactants in the middle is basically the same as the entrance. His second idea is quasi equilibrium method, that is, the slowest step in the reaction is to determine the whole reaction rate, which is called the decisive step of the reaction. aking the speed step as the benchmark, the rate of the whole chemical reaction is fitted by the reaction rate of the speed step. Due to the detailed introduction of the process of complex reaction in physical chemistry, we will not repeat it here.

4. The analogy of the multi-link income problem in the economic field

4.1. Elementary process series

For each element process, the sum of the contribution indices of each factor involved in the primitive process is called elementary progression series.

For the N reaction:

$$A+B+C... \to D$$

$$r=\frac{d[D]}{dt}=[A]^{\alpha}*[B]^{\beta}*...$$

$$\alpha+\beta+...=n$$

Among them, the index represents the weight ratio of the contribution. If the weight of the transaction is greater, the more the contribution will be made. To simplify the calculation, we define the index of the least contributing factor as 1, and other factors can be obtained by comparing the factor with that factor.

For a single primitive process, the rate of return is expressed as:

$$r=-\frac{dC}{dt}=kC^{n}$$

For the integral of the upper form, we get the final rate expression.

$$\frac{1}{C^{n-1}}-\frac{1}{C_0^{n-1}}=(n-1)kt$$

Among them, n can't be 1.

For the primitive process of n=1, it is shown that the primitive process is related only to one factor, and the rate of return of the primitive process is equal to the derivative of the element.

4.2. Typical complex processes

1) The confrontation process

In the field of economics, we will encounter a situation where A and B are involved in a primitive process. But there is interaction between A and B, that is, A generates B, and B generates A. For example, in a company, it includes processing plants (A) and restaurants (B). The raw material processing plant (A) produces disposable lunch boxes to the hotel (B) with plastic. When the disposable lunch boxes in

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hotels are turned into waste plastics and sold to raw materials processing plants, the transaction process is called confrontation process. We will express the process in the mathematical way:

$$A \underset{k_-}{\overset{k_+}{=}} B$$

t=0	$\mathbf{a_0}$	**0**
t=t	$\mathbf{a_0-x}$	**x**
$\mathbf{t=t_e}$	$\mathbf{a_0-x_e}$	$\mathbf{x_e}$

Assuming that A will not introduce more raw materials, that is, at the beginning of the process, A has all the raw materials, and B owns 0.With the change of time, A and B can reach an approximate equilibrium in the continuous trading process, that is, the raw materials provided by A and B and the recovered materials are almost unchanged as time goes on.

The rate of return of this process can be expressed as:

$$r = -\frac{d[A]}{dt} = \frac{dx}{dt} = k_+(a_0 - x) - k_- x$$

The integral of the upper form can be obtained:

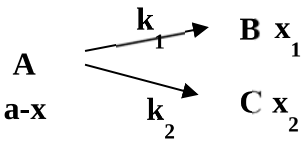
$$\ln \frac{k_+ a}{k_+ a - (k_+ + k_-)x} = (k_+ + k_-)t$$

That is,

$$x_e - x = x_e e^{-(k_+ + k_-)t}$$

2) Parallel process

In a primitive process, a raw material may correspond to several families. For example, a company includes processing plants (A), export departments (B) and retail stores (C).Part of the plastic processed by the processing plant (A) will be sent to the B (export part), while the other part will be traded with the C. The process is a parallel process.



The total return rate of the whole reaction can be expressed as: R=r1+r2

For the two forms respectively, we get the following:

$$\left.\begin{aligned} \frac{dx_1}{dt} &= k_1(a-x) \\ \frac{dx_2}{dt} &= k_2(a-x) \end{aligned}\right\} \frac{dx}{dt} = -\frac{d(a-x)}{dt} = \frac{dx_1}{dt} + \frac{dx_2}{dt} = (k_1 + k_2)(a-x)$$

Here, we think that the reaction order of B and C is n.

3) Continuous process

The process can be completed through several consecutive elementary reactions. For example, the Department (A) discarded plastic into a plastic block to transport to the Department (B), the Department (B) molding plastic blocks into various parts mold to the Department (C), C parts mold splicing, get the finished product. This process is called a continuous process.

The continuous process is expressed as follows:

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

t=0	**a**	**0**	**0**	**a=x+y+z**
t=t	**x**	**y**	**z**	

We distribute the guide, and we can get:

$$\frac{dx}{x} = -k_1 dt \rightarrow\rightarrow x = ae^{-k_1 t}$$

$$\frac{dy}{dt} = k_1 x - k_2 y$$

$$dy = (k_1 a e^{-k_1 t} - k_2 y)dt$$

$$\begin{cases} y = \dfrac{k_1 a}{k_2 - k_1}(e^{-k_1 t} - e^{-k_2 t}) \\ x = ae^{-k_1 t} \\ z = a - x - y = a[1 - \dfrac{k_2}{k_2 - k_1} e^{-k_1 t} + \dfrac{k_1}{k_2 - k_1} e^{-k_2 t}] \end{cases}$$

By integrating, we can get the final result of three factors.

4.3. Approximate treatment of composite reaction

For many complex reactions, there is not only a confrontation but also a parallel reaction and a series of reactions. For these reactions, it is very difficult to deal with the results by solving the differential equation method. For this reason, we use the quasi steady state method and quasi equilibrium method to deal with the compound reaction.

1) Quasi steady state method

In a complex reaction containing a series of reactions, a certain intermediate is easily consumed after the formation of an intermediate, that is, after a period of time, the unstable intermediate reaches the "approximate stability state". The derivative of the unstable product at this time is 0.The rate of return can be obtained through this breakthrough.

Take a company for example. The company contains two primitive processes. The first process is the processing plant (A) to deliver the pulp to the company (C), and the company (C) turns pulp into paper. The company (C) and the packaging company (B) jointly sell paper to the market intermediary (P). C will produce unavoidable waste paper in production, which will be packaged and returned to the processing plant (A).

$$A \underset{k_{-1}}{\overset{k_1}{=}} C$$

$$C + B \xrightarrow{k_2} P$$

The production rate of paper can be expressed as:

$$\frac{d[P]}{dt} = k_2 [C][B]$$

The company (C), we think, is an unstable intermediate, that is, the paper produced will enter the next step quickly. As a result, the change in time should be approximately 0:

$$\frac{d[C]}{dt} = k_1[A] - k_{-1}[C] - k_2[C][B] = 0$$

Then: $[C] = \frac{k_1[A]}{k_{-1} + k_2[B]}$

Therefore,

$$\frac{d[P]}{dt} = \frac{k_2 k_1[A][B]}{k_{-1} + k_2[B]}$$

2) Quasi equilibrium method

In a series of reactions, if the reaction rate is slower than the other steps, the overall reaction rate of the consecutive reactions is equal to the rate of reaction. This step is called the rate-determining step. The total rate equation and rate constant depend only on the rate-determining step and the front equilibration process, which are independent of the reaction process after the rate-determining step. The concentration of intermediates is calculated according to the reaction equilibrium constant and relative species concentration.

For example, when a factory circulated something, it has the following links:

(1)	$A + B \rightleftharpoons C$	**k_1**
(2)	$C + D \rightleftharpoons E$	**k_2**
(3)	$E \rightarrow F$	**k3 (slowest)**
(4)	$F \rightarrow P$	**k_4**

Since (3) is the slowest, the rate of the whole process can be expressed as:

$$r = \frac{d[P]}{dt} = k_3[E]$$

Since (3) is the slowest step in a series of processes, the two processes can achieve an approximate equilibrium state.

$$[E] = K_2[C][D]$$

$$[C] = K_1[A][B]$$

Therefore, the total rate is as follows:

$$r = k_3 K_1 K_2 [A][B][D]$$

5. Analysis of the actual rate of return of the company

We take the toy production of all departments in a company's annual report as an example to verify the feasibility of our model.

Define:

$$rmp = raw\_material\_plant$$
$$pd = production\_department$$
$$qid = quality\_inspection\_department$$
$$ed = expert\_department$$
$$rd = retail\_department$$

We can have:

$$rmp_1 + rmp_2 \rightarrow pd_1$$
$$rmp_3 \rightarrow pd_2$$
$$pd_1 + pd_2 \rightarrow pd_3$$
$$pd_3\ f \quad qid$$
$$pd_3\ f \quad pd_1$$
$$qid \rightarrow rd + ed$$

According to the quasi steady state method, we can get two equations:

$$\frac{d[pd_2]}{dt} = 0 = k_2[rmp_3] - k_3[pd_1][pd_2]$$
$$\frac{d[pd_1]}{dt} = 0 = k_1[rmp_1][rmp_2] - k_3[pd_1][pd_2] + k_5[pd_3]$$

The daily circulated data in the company's statements are as follows: (the data in the table has been divided by 1000)

Table 1. The daily circulated data in the company's statements

	Raw material plant 1	Raw material plant 2	Production department 1	Production department 2	Production department 3	Quality inspection department	Export department	Retail department
Daily circulation of toys	4.63	2.12	6.69	4.30	3.87	3.79	2.10	1.34

Substituting the above data into the formula, the result is:
r=3.73
Compared with the actual data in the report, the error is 3%, within acceptable error.

6. Conclusion

By analogy with the idea of complex reaction processing in chemical kinetics, we simulated the behavior in the field of economics. The analogy in the chemical reaction defines the economic behavior such as the basic element process, the confrontation process, the continuous process and so on. The reaction is approximated by the quasi steady state method and the quasi equilibrium method. Finally, through the test with actual company data, the fitting effect is good, indicating that this method has certain practical value in real life.

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