On Reliability Improvement of S.D. Model

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Abstract

This article expounds the necessity of improving reliability of the S.D.model and based on the concepts of "BIG SYSTEM", "STRICTNESS" and "PARAMETER ACCURACY" when developing a model puts forward some tentative methods to improve reliability of the S.D. model.

Preface

When we are developing a new model, we mean to study a certain system and to learn its performing mechanism, we mean to work out the necessary counter-measures and relevant policies so that we may achieve our set goal and realize effective control over the system. Then to what extent will a S.D. model reflect the regular performing activities of an actual system and to what extent can the primary resolutions on the system be taken as reliable? These will, more than often, influence greatly or even determine the whole process of decision-making. A seriously distorted model and the results worked out with it will undoubtedly lead the decision-makers to astray, and this in turn will endanger the realization of the set goals when developing the model. It is in the nature of things the reliability of a model to become the utmost concern for all decision-makers. This article is to expound some tentative methods for improving the reliability of the S.D.model.

1. Introduction of "Big System" Concept into Development of S.D. Model

A system, in general, is a setof different yet interacted parts combined closely to perform a commmon function for the same goal.[1] A system may be big as well as small depending on comparison.[2] Any objective we are studying can be regarded as a smaller system (A), which is included in a bigger system (B), that is A $\subseteq$ B, therefore, the funcrion and behavior of system (A) is necessarily restricted by system (B). In this case he who wants to obtain a comprehensive and accurate understanding of system (A) must not confine his study in system (A) only, instead ,he should make considerable efforts to study system (B), especially factors closely related to system (A) and other interaction and interrelation between the two systems. Only in this way can he get to know the mechanism of system (A) by nature and the behavior of system (A) on the whole; can he avoid being one-sided and ignoring the relevant key factors when developing a model hence the great improvement of reliability in developing a model. For example, once we are set to study the tendency of cotton textile industrial development ina certain area then work out the effective counter measures, we shoule be engaged not only in the research into the development pattern of the cotton textile industry, into the raw material supply, into the marketing, and technological development trend, but also in the research into the development trend of the entire industry including woolen tixtile, flax textile, silk weaving and artificial fabrics, and into their effects on the cotton textile industry. For another example, the study of population. In order to gras the core of the population growth tendency accurately and put forward counter-measures for population control right to the point, one must not only study the development pattern and tendency of the population system proper, but also study the supporting abilities and shifting trends of those systems as economics, society and national environment that the population system falls within, and study their influences upon the population growth.

Generally speaking, when we are making a research into problems concerning regional economic development strategics and counter-measures, it is altogether necessary for us to perform a careful study of the economic system, which includes all economic sectors in the region. Yet it is far from enough. We must take all those factors following into our consideration as well: the regional scie-tech system and the economic society system that closely related to the economic system; the State and even international scie-tech system and the economic society system; and their ever shifting trends; the post-effects on regional economic development; and interrelationship changes triggered off by the State and international systems. It is boosting to say that we have had a thorough understanding of the regional economic development trends before we have all abovementioned researches done.

2. Introduction of "Strictness" Concept into Development of S.D. Model

The simulation of a S.D. model is of a structural and fuctional kind. When a S.D. model is being developed, special attentionshould be paid to the internal micro-structures of the system and the information feedback mechanism of the system, in which the behavior pattern of the system is deeply rooted. Then with the help of the simulation technique of a computer, one may analyse the relationship within the systematic structural function and the dynamic behavior, and work out the countermeasures to solve the problems. Therefore, the most important things before using a S.D. model to do some research work methodologically are to study and analyse the system proper thoroughly and comprehensively so as to grasp its nature, to know clearly the interactions of the main feedback loops and influences upon the systematic behavior. The author believes that the behavior of any comparatively independent system would fall into a pattern of its own, otherwise the system would not be an independent one; and the only way to precisely illustrate the behavior pattern of a system is to use mathematic expressions, which would depict accurately the operating characteristics of the system. It is evident that a model such developed would be significantly improved in its reliability and practicability, and the emulation program for countermeasures, optimum seeking and countermeasure suggestions worked out would, no doubt, be of great importance and reliability to those decision-making bodies as well as persons. That explains why we insist that much attention be paid to the strictness especially when developing a model.

Let's take population growth for example and study the natural birth - death process in a region. If a stands for the age, t for time, Δa for a considerably small span of the age, $\Delta a > 0$, then the total population between ages $[a, a+\Delta a]$ at the certain time t will be $p(a,t)\Delta a$, ($p(a,t)$: function of the age distribution density of a population). As time Δt passes on to time $t+\Delta t$ some poeple will have died for some reasons, and the death number will be $\mu(a,t)p(a,t)\Delta a\Delta t$ ($\mu(a,t)$: function of a comparative death rate), and the rest keeping alive by the time $t+\Delta t$ will be at the age of $[a+\Delta a', a+\Delta a + \Delta a']$, since both a and t have the same dimension, $da/dt = 1$, thereforth $\Delta a' = \Delta t$, and by the time $t+\Delta t$, the total number of people at the age of $[a+\Delta a', a+\Delta a+\Delta a']$ will be $p(a+\Delta a', t+\Delta t)\Delta a$, hence the equation:

$$p(a,t)\Delta a - p(a+\Delta a', t+\Delta t)\Delta a = \mu(a,t)p(a,t)\Delta a\Delta t, \quad \text{[3]} \quad \ldots\ldots\ (1)$$

Considering the factor of immigration, then:

$$p(a+\Delta a', t+\Delta t)\Delta a - p(a,t)\Delta a = -\mu(a,t)p(a,t)\Delta a\Delta t + g(a,t)\Delta a\Delta t, \quad \ldots\ldots\ (2)$$

With Δa being taken off, equation (2) will be:

$$p(a+\Delta a', t+\Delta t) - p(a,t) = -\mu(a,t)p(a,t)\Delta t + g(a,t)\Delta t, \quad \ldots\ldots\ (3)$$

In order that the population growth equation can be also available for computer processing, a, t in the equation are, as usual, the integers. $x_i(t)$ for the totall number of people at the age of i (not exceeding i+1) in the year of t, i will be an integer (0, 1, 2, 3, 4, 5 .....etc) i.e.

$$x_i(t) = \int_i^{i+1} p(a,t)\,da, \quad i = 0, 1, 2, \cdots, m, \quad \ldots\ldots\ (4)$$

Integrating a on the both sides in equation (3) from i to [i+1], and assuming $\Delta t = 1$, then based on (4):

$$x_{i+1}(t+1) - x_i(t) = -\int_i^{i+1} \mu(a,t)p(a,t)da + \int_i^{i+1} g(a,t)da, \quad i = 0, 1, \cdots, m-1, \quad \ldots (5)$$

Applying the intermediate value theorem to the first right term, then:

$$\int_i^{i+1} \mu(a,t)p(a,t)da = \mu(\xi,t)\int_i^{i+1} p(a,t)da = \mu(\xi,t)x_i(t), \ \xi \in [i, i+1];$$

Provided $\mu(\xi,t)$ meet the following:

$$\inf_{i<a<i+1} \mu(a,t) \leqslant \mu(\xi,t) \leqslant \sup_{i<a<i+1} \mu(a,t) \quad \ldots\ldots\ldots (6)$$

$\mu_i(t) = \mu(\xi,t)$ is the death rate of those who age [i] in the year of [t], then equation (5) will be:

$$x_{i+1}(t+1) = x_i(t) - \mu_i(t)x_i(t) + g_i(t),$$
$$i = 0, 1, 2, \cdots, m-1,$$

In the equation $g_i(t) = \int_i^{i+1} g(a,t)\,da$, da, this indicates the total number of people at the agr of [i] yet not exceeding [i+1] who immigrate or migrate during the time from year [t] to year [t+1].

Let's assume that $\varphi(t)$ is the total number of babies born in the whole year of [t] by women of child bearing ages [a_1, a_2], [t] is the average birth rate of women in a year, $k_i(t)$ the female proportional function, $h_i(t)$ the birth pattern, then:

$$\phi(t) = \varphi(t)\Delta t = \beta(t)\int_{a_1}^{a_2} k(a,t)h(a,t)p(a,t)da$$

$$= \beta(t)\sum_{i=a_1}^{a_2}\int_i^{i+1} k(a,t)h(a,t)p(a,t)da. \quad \ldots\ldots\ldots (8)$$

Applying the integral intermediate value theorem to the right side of the above equation:

$$\int_i^{i+1} k(a,t)h(a,t)p(a,t)da = k(\xi,t)h(\xi,t)\int_i^{i+1} p(a,t)da \qquad \xi \in [i, i+1];$$

given $k_i(t) = k(\xi, t)$, $h_i(t) = h(\xi, t)$. then:

$$k(\xi,t)h(\xi,t)\int_i^{i+1} p(a,t)da = k_i(t)h_i(t)x_i(t) \qquad \xi \in [i, i+1];$$

If we substitute the equation above instead of equation (8), then:

$$\psi(t) = \beta(t) \sum_{i=a_1}^{a_2} k_i(t)h_i(t)x_i(t), \qquad \ldots\ldots\ldots (9)$$

in the equation above, $h_i(t)$ can meet the normalized conditions $\sum_{i=a_1}^{a_2} h_i(t) = 1$

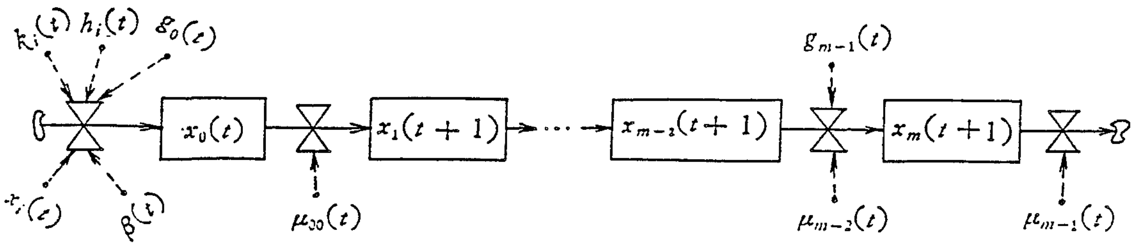
If $x_0(t)$ is the total unmber of babies that live up to the year of $[t]$, and $\mu_{00}(t)$ is the deathrate of babies during years from $[t-1]$ to $[t]$. Then:

$$x_0(t) = (1 - \mu_{00}(t))\psi(t). \qquad \ldots\ldots\ldots (10)$$

Combining equations (6), (9) and (10), we will get a set of difference equations, in another word, a complete set of equations of the population growth:

$$\begin{cases} \psi(t) = \beta(t) \sum_{i=a_1}^{a_2} k_i(t)h_i(t)x_i(t) \\ x_0(t) = (1 - \mu_{00}(t))\psi(t), \\ x_1(t+1) = (1 - \mu_0(t))x_0(t) + g_0(t), \\ x_2(t+1) = (1 - \mu_1(t))x_1(t) + g_1(t), \\ \ldots\ldots \\ x_m(t+1) = (1 - \mu_{m-1}(t))x_{m-1}(t) + g_{m-1}(t). \end{cases}$$

The difference equations above can also be converted into a set of matrics which would not be illustrated here, yet its S.D. flow diagram is as follows:



It is easy enough to deduce the DYNAMO equations from the difference equations and the flow diagram. The author believe every system has its own nature, only by means of careful study, can one get to know its nature, can one describe the mechanism and behavior pattern of the system accurately in the form of mathematic expressions. In short, we should pay much attension to the "strictness" concept when developing a model.

3. Introduction of Parameter Accuracy Concept into Development of S.D. Model

Since a S.D. model is specifically developed to show the feedback relationship, therefore its behavior pattern will be inert to parameter changes. Yet this is not necessarily to mean that parameters for a S.D. model can be carelessly selected, and only the contrary is true. It is so simply because that no matter how strict in developing a model, and how precise in describing the nature of system behavior in mathematic expressions, the emulation result value would be definitely in correct if the parameters selected are not correct. And no matter what efforts in improving the model hence made will not compensate the losses resulted by parameter errors. Let's take above discussed population growth for example. If the equations are correct, but the parameters put into the equations are incorrect, how can we expect the emulation results worked out to be correct! From above, it may be clear that we should not only pay much attension to study of the basic structure of a system and various feedback relations when manipulating S.D. method in our reseach, but also emphasize the correctness of parameters. The author thinks that historic parameters should be selected out of good sources; abnormal parameters should be carefully verified; parameters concerning future development tendency should be evaluated by adopting various kinds of scientific methods; and additional care should be given to avoid one-sided conjecture in selecting the table functions.

Conclusion

The reliability of a S.D. model will be greatly improved if a careful study is made and special attention is paid to the abovementioned three aspects when developing the model. It can be taken as granted since it has already be proved successful as the author applied the three concepts to the researches into Rational Development of Water Resources in Xinjiang and Its Economic Development.

Reference:

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