A STUDY OF SENSITIVE TEST

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ABSTRACT. It is necessary to test a newly built model to make sure that it does simulate the actual system. The test may include many aspects, such as sensitive test, comparison test with history data, etc. This paper studies sensitive test and presents some result of the findings.

In studying the structure of a given system, the endogenous variables and exogenous variables are given explicitly. If we can not tell the difference between them correctly,it may confuse the real meaning of the sensitive test.

In the present analysis we find that the conditions for non-sensitivity of variables to a model are: 1) the change is made for one variable only and 2) the change is small. The conditions for sensitivity of variables to a model are: 1) two or more variables change at the same time and 2) the change is great. A model may also become sensitive for a small change of the exogenous variable.

The above results have been thoroughly investigated and the methods of sensitive test are presented.

The system always changes from one stable condition to another stable condition in which it is non-sensitive to variable changes, but if the system is in a state between two stable conditions, it is completely possible to become sensitive to variable changes. So we may point out that the model builder and analyst are required to find out the correct boundary of stable conditions.

Finally, the simple economic long wave model is tested to confirm the above results.

Recent evidence (System Dynamics Review vol.4,No.1-2,1988) points chaotic modes do exist in the range of models commonly explored by most students and practitioners of System Dynamics. Experiments also demonstrated that chaos can in fact be produced by decision-making processes of real people. Chaos thus appears to be a common mode of behavior not only in physical systems, but also in social and economic systems. However, chaos is a steady-state pheonomena over very long time frame and many policy-oriented models are concerned with transient dynamics with time horizon much shorter than those used in chaotic dynamics. Over such extended time horizons the parameters of the system can't be considered static, but will themselves evolve with learning and evolutionary processes.

With such a viewpoint in mind we have explored a study of sensitive test in the following way.

I. The basic criterion of sensitive test

Which system is called stable or unstable system ? A stable system is that its property (behavior) is regular and varies with the regularity. An unstable system is that its property can't be found regular. In fig.1, we suppose curve 1 stands for the behavior of system 1, curve 2 for system 2. We can see the system 1 is stable because the variation of curve 1 is regular (periodic oscilation). System 2 is unstable.

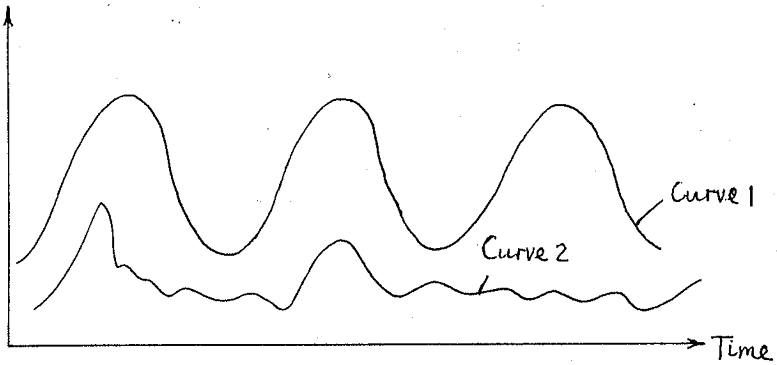

Fig 1: curve 1 for system 1, curve 2 for system 2

We have learned that a model to be effective must be non-sensitive to its endogenous variables without changes of exogenous variables. This principle must be looked for in the characteristics of a real system. In so doing we consider the system to be dealt with must be non-linear either in a stable or unstable state.That means the system is either in a steady-state pheonomena, or varying with transient dynamics tending to be stable on its time horizon. We can't imagine that a system is in a position of unstable state for ever with no changes of exogenous variables. So in the following analysis we shall discuss on the premise that a system itself has always a tendency to become stable without changes of exogenous variables.

By endogenous variables we mean those variables being determined by the inner structure of a system and by exogenous variables we mean those variables not included in the inner system structure. They both have effects on the behavior of the system but of different nature. The former is non-sensitive to the system, which the latter is tending to change the system from stable state to unstable state.

That a system has a tendency to be stable doesn't mean the system doesn't change. In the real system, exogenous variables always changes and these changes will cause the behavior of the system changes slightly or violently. So the system in the real world is always changing in process of being stable-unstable-stable... and so on. Now we may conclude that the only way for a stable system to become unstable is due to the variation of exogenous variables and a system is non-sensitive to its endogenous variables.

In the following analysis, let us call endogenous variable a variable and exogenous variable a parameter for simplicity in writing.

II. Three principles of sensitive test

We present here three principles for sensitive test giving clear indications for a stable system.

Principle 1: A tiny variation of a variable can't cause the system behavior to change greatly. A system is always non-sensitive to its variable.

The charicteristic of a system having a tendency to be stable assures that principle 1 is tenable. If a model reflects a system correctly but is sensitive to a variable, we can be sure that the system is in a position of unstable state.

Principle 2: If two or more variables make tiny variations at the same time, it may cause a system behavior to change greatly.

When several variables make tiny variations at the same time and if these variables' effects offset each other, it may have little effect on the behavior of a system which is non-sensitive. But if these variables' effects amplify each other, the behavior of the system which is sensitive may have great changes. So we can't guarantee a system being non-sensitive to tiny variations of several variables at the same time.

Principle 3: It may cause the behavior of a system to change greatly if a variable has a great change.

A system is non-sensitive to a tiny variation of a variable, but if the variation becomes great enough, it may certainly make the system to change greatly.

III. Sensitive test and policy analysis

Sensitive test and policy analysis both examine the behavior of a system by changes of variable and parameter. But the former use endogenous variables and the latter use exogenous variables for the test and analysis, respectively.

A parameter's effect on a system is witnessed by variables, so we can discuss policy analysis more easily with the help of sensitive test.

If change of a parameter only makes a variable tiny change, we can see the system must be non-sensitive to the parameter according to principle 1; If change of a parameter makes a variable great change or makes several variables change together, the system may be sensitive according to principle 2 and 3.

We have know that a system always changes from a stable state to an unstable state, there must exist a boundary for a variable within which the system will be stable no matter how the variable changes. A good model builder will not only examine the sensitivity of the system, but also find the stable boundary of variables. If he (or she) can make it, certainly it's helpful for a decision maker to get more correct decisions.

IX. Sensitive test for a simplified economic long wave model

Fig.2 shows a flow diagram of the said model and Fig 3 shows a simulation of it (equations are in appendix). Where ALC, DPG, DDC, COR are parameters and the others are variables. Through the test we find the model is non-sensitive to variables.

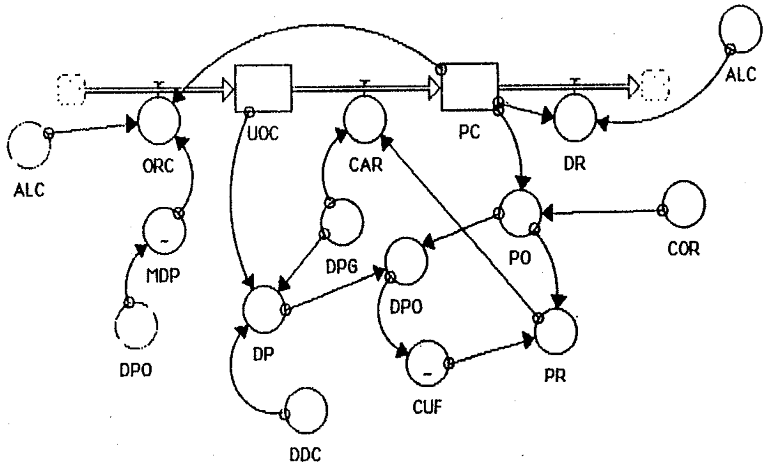

Fig.2 S.D. flow diagram of said model

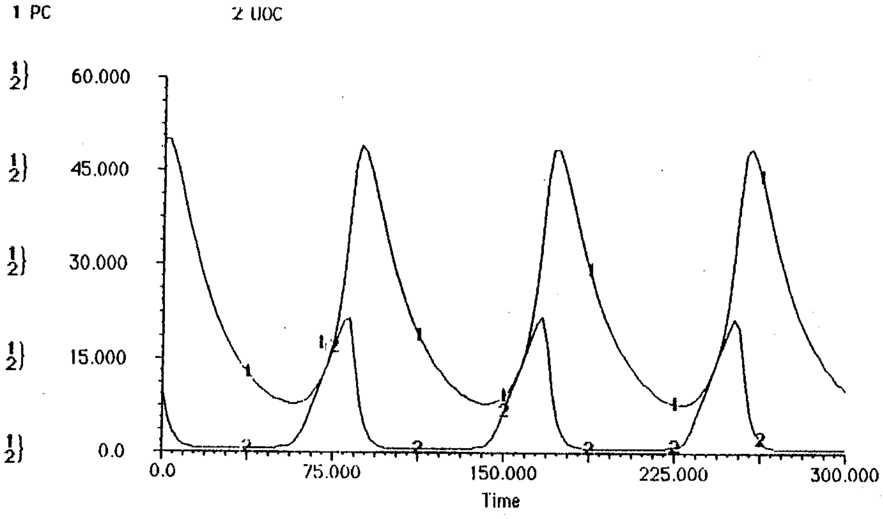

Fig.3 Simulation result for said model

ALC=20, DDC=3, COR=6

Fig.4 shows the result of test with variable PO amplified 1.1 times as Fig.3 (Now·PO=(PC/COR)*1.1, compared with PO equation in appendix). Compared with Fig.3, we see that the original behavior of the model doesn't change (periodic oscilation). If we let CAR be amplified 1.1 times as Fig.2 and DR 0.9 times respectively, the results are similar to Fig.3. So the model is non-sensitive to the variables.

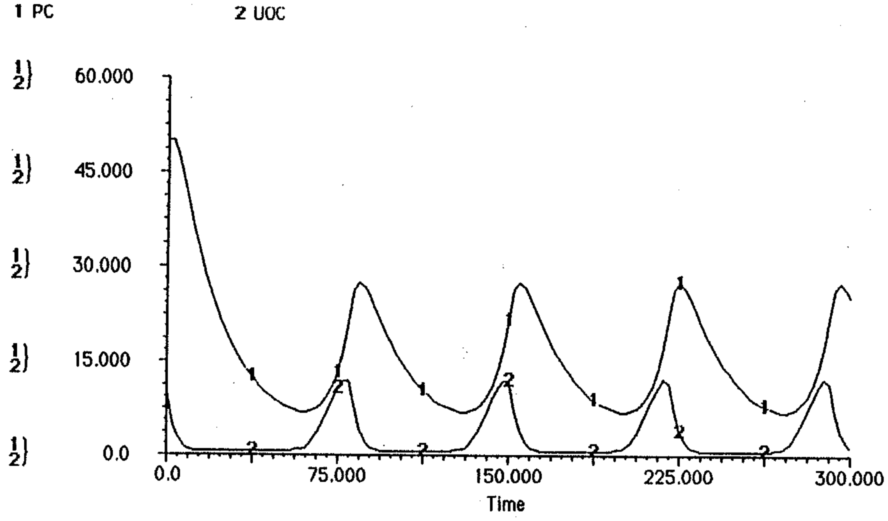

Fig.4: amplifying PO 1.1 times

Now let the two variables CAR,DR change at the same time, with CAR amplified 1.1 time as Fig.3 and DR 0.9 times. The result is shown in Fig.5. The behavior of the model is changed from a periodic oscilation to an approximate steady line. It means that the model is sensitive to the two variables changing at the same time. This is in accordance with principle 2.

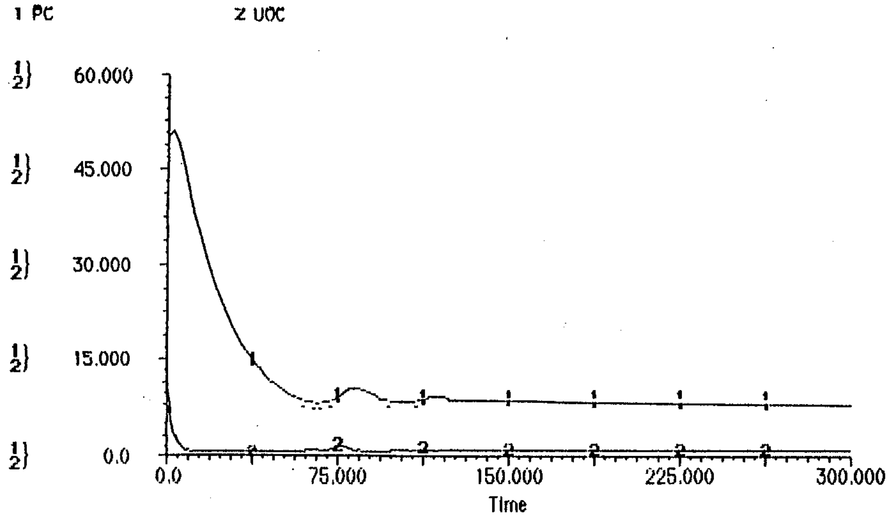

Fig.5: amplifying CAR 1.1 times and DR 0.9 times

Fig.5: amplifying CAR 1.1 times and DR 0.9 times

From Fig.4, we see that the model is non-sensitive to the tiny variation of PO, but if PO changes greatly, say amplified 1.5 times original equation, the result is similar to Fig.5. The model exhibits sensitivity to the variable PO great change. This is in accordance with principle 3.

Now suppose our aim is to make the behavior exhibit an approximate line. This aim can easily be reached by taking PO 1.5 times the original equation. In eq.PO.K=PC.K/COR, the aim can also be reached by changing parameter COR from 6 yr to 4 yr. That means if capital-output ratio could be made 4 yr, the economic long wave may disappear.

If we lower the variable DR(depreciation rate), the peak of the periodic oscilation will become small,What does it mean ? From eq. DR.KL=PC.K/ALC, we can see that lowering DR means enlarging ALC (average lifetime of capital). That is to say, if ALC is enlarged, the economic wave oscilation could be make smaller. But in the present real world the eliminating period of capital is, in fact, becoming shorter and shorter. It will certainly cause more periodic oscilations of economy in the world.

From above analysis, it is quite clear that the study of sensitive test as outlined in this paper is very useful and helpful to those who are involved in sensitive test, policy analysis and decision making. The authors hope that after being familiarised with the newly published issues of chaos, the present study may be further elaborated at a later date.

Reference

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Apendix: the equation of a simplified economic long wave model

L	PC.K=PC.J+DT*(CAR.JK-DR.JK)	production capital
N	PC=50	
L	UOC.K=UOC.J+DT*(ORC.JK-CAR.JK)	unfilled orders for capital
N	UOC=10	
C	ALC=20	average lifetime of capital
R	CAR.KL=PR.K-DPG	capital acquisition rate
C	COR=6	capital / output ratio
C	DDC=3	desired delivery delay
A	DP.K=UOC.K/DDC+DPG	desired production
C	DPG=1	desired production of goods
A	DPO.K=DP.K/PO.K	desired production/potential output
R	DR.KL=PC.K/ALC	depreciation rate
R	ORC.KL=(PC.K/ALC)*MDP.K	order rate for capital
A	PO.K=PC.K/COR	potential output
A	PR.K=PO*CUF.K	production rate
A	CUF.K=TABLE(TCUF,DPO.K,0,0.2,2)	capital utilization factor
T	TCUF=0/0.2/0.4/0.6/0.8/1.0/1.1/1.15/1.18/1.19/1.2	
A	MDP.K=TABLE(TMDP,DPO.K,0,0.2,2)	multiplier from desired production
T	TMDP=0/0.1/0.2/0.3/0.5/1.0/2/3/3.5/3.9/4	