

Simulation of Production and Financial Systems

The simulation plays an important role in searching of the production and financial processes. The simulation is the process of attempting to build up the model of the studied system and use it for the purposes of the system behaviour prediction.

The production and financial systems pertain to the most complicated dynamical systems. The mathematical models are possible to use for these purposes. The models of systems are simplified abstract tools which are used for the model systems behaviour prediction. The build-up process is called the modelling and its use for the model systems behaviour prediction is called the simulation.

For the purposes of simulation the system is possible to define as a part of the environment that is possible to separate by means of thought border. The system consists of the cross connected parts of the subsystems. The aim is to build up the simplest model representing the behaviour of the actual model with satisfactory accuracy. The mathematical model will be presented by the differential equation in the form of:

$$My''(t) + By'(t) + Dy(t) = 0,$$

where M is the inertial coefficient, B is the dissipative coefficient and D is the directive coefficient.

System	<u>Mechanical</u> M	<u>Hydraulic</u> H	<u>Electrical</u> E	<u>Production</u> P	<u>Financial</u> F
Force	Force LMT^{-2}	Pressure $L^{-1}MT^{-2}$	Voltage $L^2MT^{-3}I^{-1}$	Production force $L^2MT^{-2}p^{-1}$	Financial force $L^2MT^{-2}\$^{-1}$
Effort	Deviation L	Volume L^3	Charge IT	Product p	Capital $\$$
Flow	Speed LT^{-1}	Flow $L^{-3}T^{-1}$	Current I	Productivity pT^{-1}	Capital flow $\$T^{-1}$
Dissipation B	Mech. dis. coef. MT^{-1}	Hydr. dis. coef. L^4MT^{-1}	El. dis. coef. $L^2MT^{-3}I^{-2}$	Prod. dis. coef. $L^2MT^{-1}p^{-2}$	Fin. dis. coef. $L^2MT^{-1}\$^{-2}$
Directive D	Mech. dir. coef. MT^{-2}	Hydr. dir. coef. L^4MT^{-2}	El. dir. coef. $L^2MT^{-4}I^{-2}$	Prod. dir. coef. $L^2MT^{-2}p^{-2}$	Fin. dir. coef. $L^2MT^{-2}\$^{-2}$
Inertial M	Mech. iner. coef. M	Hydr. iner. coef. L^4M	El. iner. coef. $L^2MT^{-2}I^{-2}$	Prod. iner. koef. L^2Mp^{-2}	Fin. iner. koef. $L^2M\$^{-2}$

Tab.1. System analogy

Tab.1. shows this analogy for the mechanical, hydraulic, electrical, production and financial systems. When the variables (force-effort-flow) are regarded then the analogy corresponds for the mechanical system to (force-deviation-speed), for the hydraulic system to (pressure-volume-flow), for the electrical system to (voltage-charge-current), for the production system to (production force-product-productivity) and for the financial system to (financial force-capital-capital flow). Furthermore we can regard the inertial coefficient M, the directive coefficient D and the dissipative coefficient B for the mechanical system M, hydraulic system H, electrical system E, production system P and financial system F.

The first example shows the stock market model as a system with feedback. See Fig.1.

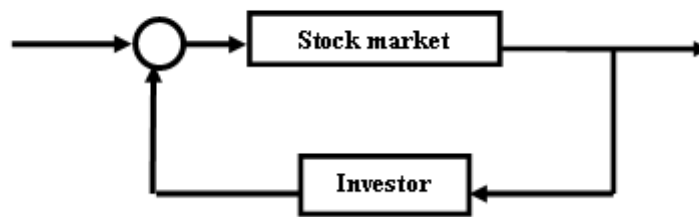


Fig.1. Stock market and feedback

This system is easily described by means of the second rate differential equation in the form of:

$$M_F y''(t) + B_F y'(t) + D_F y(t) = 0.$$

The symbols are as follows: A – input constant, M – inertial constant, D - directive constant, B – dissipative constant, S₁, S₂, S₃ – summation junctions, I₁, I₂ - integrative links.

The Fig.2. shows the equation scheme model where the feedbacks, one consisting of B coefficient and S₂ junction, the other of D coefficient and S₃ junction are noticeable. The scheme also shows that the junction S₁ calculates the sum of the input value with both feedbacks. The symbol $i_1 = x_t''$ represents the second rate derivation of the variable, i.e. the increase of the capital flow; the symbol $i_2 = x_t'$ represents the first rate deviation of the variable, i.e. the capital flow; and symbol $i_3 = x_t$ represents variable the capital. The symbol x_0' represents the initial condition for the integrative link I₁ and x_0 represents the initial condition for the integrative link I₂.

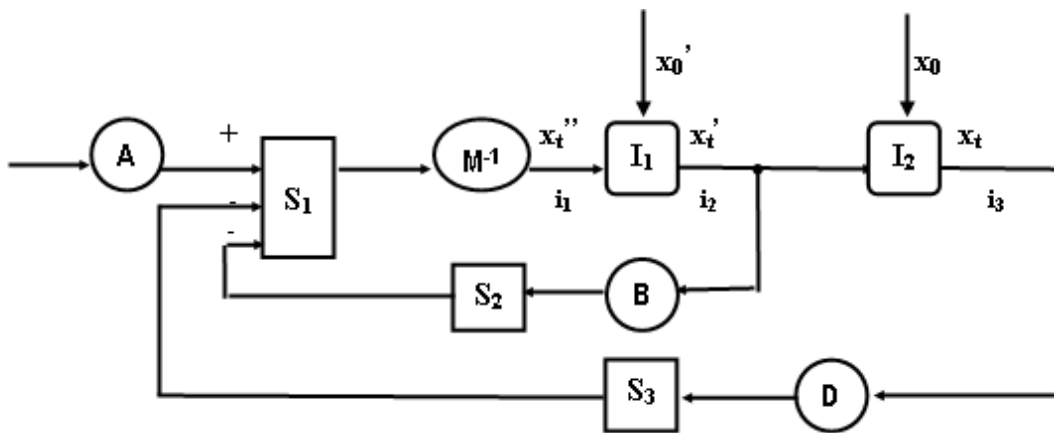


Fig.2. The scheme of model for simulation

Tab.2. represents the values of constants and initial conditions.

Name	Symbol	Unit	Value
Input constant	A _F	\$	1.0
Financial inertial coefficient	M _F	L ² M\$ ⁻²	2.0
Financial dissipative coefficient	B _F	L ² MT ⁻¹ \$ ⁻²	0.5
Financial directive coefficient	D _F	L ² MT ⁻² \$ ⁻²	32.0
Capital flow (initial condition)	F _{X0}	\$T ⁻¹	3.0
Capital (initial condition)	F _{X0}	\$	0.0

Tab.2. Table of input values

Graph is the output showing the courses of i_2 and i_3 . See Fig.3. Any calculated value can be showed.

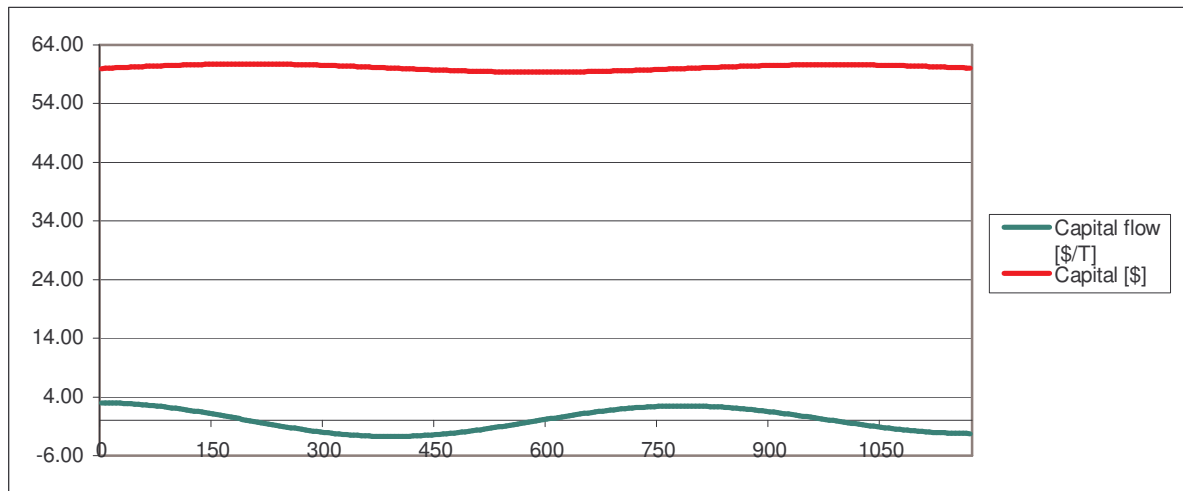


Fig.3. The graph of the output values

The graph displays the curves of the continuing the dynamic process of stock market and investors interactions. The feedback comprising the investors' reactions to the course of the stock market is rather influential in the process. The feedback can be positive or negative. The positive feedback has an amplifying effect, and also a negative influence on the stock market – investor's relation stability. The negative feedback has an attenuating effect and also a positive influence on the stock market – investors relation stability.

A further development on the stock market can be inferred from the graph and new simulations performed to predict the behaviour of the stock market.

The second example represents the production workshop model where the production and financial system will be studied. The model has a feedback when we use the differential equations in the form of:

$$M_P y''(t) + B_P y'(t) + D_P y(t) = 0 \quad \text{and} \quad D_F y'(t) = 0.$$

It is necessary to build up the schema of the action in the workshop first before we perform the simulation of these equations. See Fig.4. where index P stands for the production system and index F for the financial system.

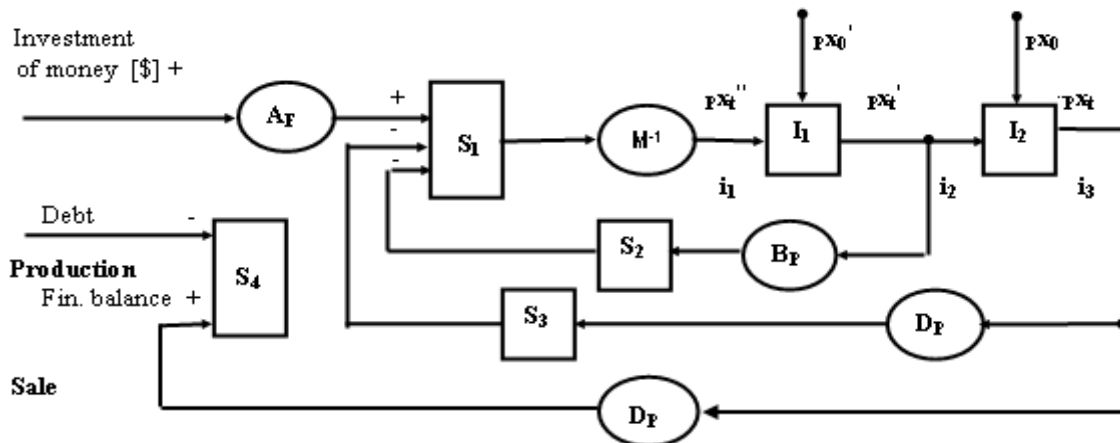


Fig.4. The scheme of model for simulation

Tab.2. shows the constants and initial conditions values.

Name	Symbol	Unit	Value
Input constant	A_F	\$	1.0
Production inertial coefficient	M_P	$L^2M\$^{-2}$	$(D_V * T)^2$
Production dissipative coefficient	B_P	$L^2MT^{-1}p^{-2}$	$2 * \sqrt{(M_V * D_V)}$
Production directive coefficient	D_P	$L^2MT^{-2}p^{-2}$	350
Financial directive coefficient	D_F	$L^2MT^{-2}\$^{-2}$	400
Productivity (initial condition)	pX_0	pT^{-1}	0.1
Product (initial condition)	pX_0	P	0.05
Time	T	T (min)	480

Tab.3. Table of input values

Graph is the output where $i_2 = \dot{v}x_t$ is the course of the first derivation of a variables, i.e. the productivity, $i_3 = vx_t$ is the course of the variable in time, i.e. the product. Next e.g. the S_4 junctions (representing balance) can be further studied. See Fig.5. Any calculated value can be showed.

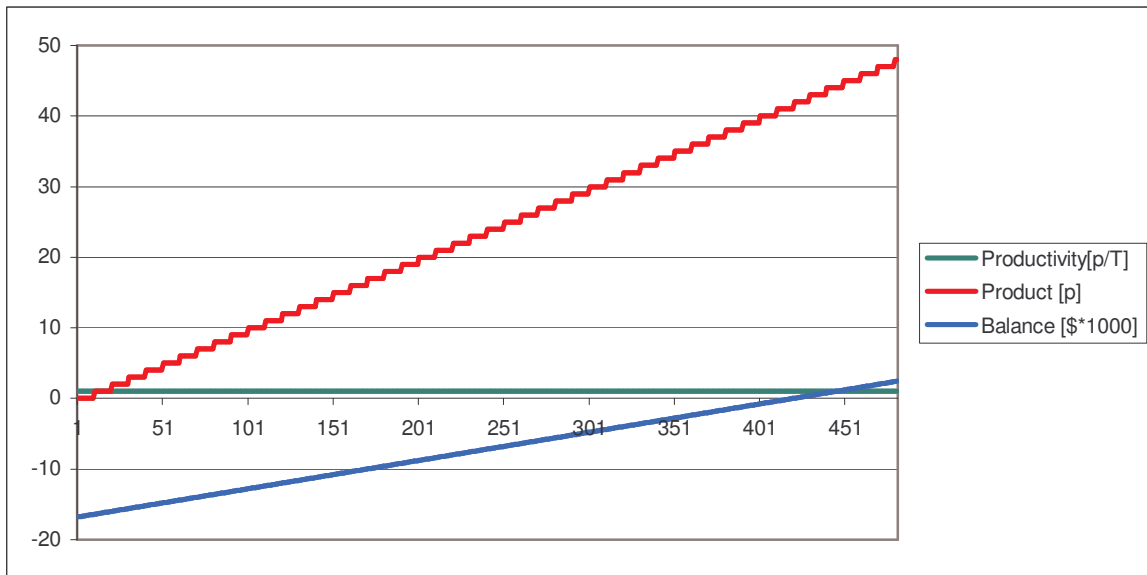


Fig.5. The graph of output values

The graph displays the curves of the dynamic process. The process of production starts when money has been invested. The production cycle can be evaluated in a graph where we can study e.g. the courses of variables i_2 , i_3 and S_4 junctions. It is interesting to study the S_4 junction where the financial balance is calculated, that is, if and when the production brings profits or losses. The start means investment in production and the end the final profit during one shift. A further development on the stock market can be inferred from the graph and new simulations performed to predict the behaviour of the stock market.

The problem is to set the coefficients M, B, D when we calculate the simulation of the production and financial systems. It is not the problem with other systems (e.g. the setting of resistance, capacity, and inductance in electrical system). If we build up the correct description of the production and financial systems we can connect them with other systems. This way it is possible to simulate the energy systems which comprise the mechanical, hydraulic, electrical, thermal, etc. systems and connect them with the production and financial systems. In such systems we can study the influence for example of the change of the electric

variables on the financial system and thus dynamically simulate the possible change of the financial balance – profits or losses.

The inertial coefficient of the production and financial systems is influenced by the operating structure, the personality and quality of the boss, workshop relations, and education. The directive coefficient D and the dissipative coefficient B of the production and financial system are influenced by running costs, prices of inputs, wage policy in production, premium and social measures, political influence, etc. The setting of these parameters is very complicated and for their correctness it is necessary to use the active search and estimation of the parameters' values, for example sociological researches.

On the basis of physical systems stating that the oscillatory element is characterized by its own frequency $\omega_0 = \sqrt{D/M}$ the functional dependence $M_V = (D_V * T) * (D_V * T)$ and $B_V = 2 * \sqrt{M_V * D_V}$ was discovered. The real frequency is influenced by the dissipative parameter B . The actual frequency has to be the highest for the fastest reaction of the system. In this case M must be of the smallest value, D the biggest and B must be of such value to avoid oscillation.

The various programs developed for simulation can be used, for example the programme Simulink which is a part of the programme MATLAB by the U.S. firm MathWorks Inc.