

“Essence of Feed-back Mechanisms Used in Systems Management”

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CHAPTER 1

MACROECONOMIC PROCESSES MANAGEMENT

Essence of Feed-back Mechanisms Used in Systems Management

Leonid Melnik^{*}

Introduction

Functioning of any system is inexorably connected with changes of its state. The matter is that its main subsystems can function effectively within a very narrow range of optimum parameters. Any deviation from the given parameters requires compensation, which is called feed-back mechanisms. The system's stability, existence and integrity in general depend on how effectively it fulfils its corrective functions.

1. The notion of the feed-back mechanisms

As a rule, any changes within the system's functioning are connected with changes of environmental conditions

For example, temperature, pressure, electromagnetic charge, substance composition, etc. can vary. This variability is not dependent on the system. The system cannot remove it, at least within adequately short periods of time, that is quickly enough to relieve the condition of the system. (Later we will make certain that the system tries to do so). It means that the system must change itself. But it cannot change the basic parameters of its homeostasis, its dynamic equilibrium. The system has adapted to exist within the given range of energy potentials difference (e.g. body temperature, blood pressure). This range provides the basic vital (without inverted commas for living beings and with such for inbiotic structures) parameters of system's existence.

Note

Unless otherwise specified, the system cannot really vary (in significant ranges) the parameters of its current homeostasis. But it can, under certain conditions, completely change the level of homeostasis itself, elevating or lowering it.

Having created feed-back mechanisms, nature solves the problem brilliantly.

Feed-back is the *reverse influence* of something (in our case a system) on *what it is influenced by*. For example, the system can influence the environmental factor that affects it either enhancing or quenching it.

This factor can be of mechanical, adiabatic (thermal), electromagnetic, chemical etc. nature.

Negative feed-back is distinguished, when the system's behaviour weakens the action of the affecting factor, while positive reverse feed-back is spoken of when the system strengthens it.

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2. The Mechanisms of negative reverse feed-back

In case of *negative feed-back* the system switches on its ancillary mechanisms to compensate changes in environmental influence. The direction of these mechanisms is opposite to the direction of environmental influence. That is why they are called mechanisms of *negative feed-back*. We face them every day.

Details

Rocking in one direction in a bus, we make ourselves steady bending another direction. Our body retains constant temperature but it perspires bringing out extra heat, when temperature increases. We drink water more often. If it is cold the reverse process occurs: pores close, evaporation reduces, unnecessary stores of energy are removed but in a different way.

The mechanisms of *negative feed-back* operate in the natural environment (this refers to the regulation of feed-back in such systems as “beast of prey – victim”) and in the society (maintaining market equilibrium “demand – supply”). The majority of technical regulating appliances are based on the usage of this mechanism. The action of *negative feed-back* was scientifically generalized by Le Shatel’e (1884) and C. Brown (1887) on the example of thermodynamic systems. Le Shatel’e – Brown’s principle in its modern interpretation means *that stationary system, removed by the interior influence from the condition with minimum entropy production, stimulates the development of processes, directed to the decrease of interior influence*. (Source: Dubnischeva and others, 1998).

Details

In living organisms the functions of *negative feed-back* are performed by the system of physiological regulation mechanisms.

The central nervous system and especially cerebral cortex fulfil the most important integrating function. The influence of sympathetic nervous system as well as the condition of hypophysis and other endocrine glands are of great importance. The example of a difficult homeostatic system that includes different mechanisms of regulation is the system that provides optimum arterial pressure level. It is regulated on the principle of chain reactions with reverse feed-back: blood pressure changes are perceived by baroreceptors vasculars, the signal is conveyed to the vascular centres, and the changes of their condition lead to the change of vascular tone and functioning of the heart. The system of neurohumoral regulation is switched on simultaneously and blood pressure returns to the norm.

Breaking of mechanisms that provide the basis for homeostatic processes are treated as “homeostasis diseases”. Functional distortions of normal organism activity connected with the reconstruction of biological rhythms can be attributed for them. Cognition of human homeostasis regularity plays a very important role in choosing effective and rational methods of treatment.

In terms of plants plasmalemma and tonoplast appear to be of paramount importance for homeostasis regulation on the cellular level. The former regulates the inflow of nutritious ions and water from the environment and release of ballast and excess ions H^+ , Na^+ , Ca^+ , the latter – the supply of standby substratum from vacuole in case of its deficit and removal in vacuole in case of its excess (vacuoles are cavities filled with cellular liquid). Stabilization of osmoatic cellular potential is carried out by means of maintaining definite intracellular concentration K^+ and anions. On the tissue level plasmadesma (special feed-back between cells), that regulates intracellular flows of carbohydrates and others substrates, takes part in homeostatic maintenance. (Biological, 1989).

One can identify several directions of *negative feed-back* mechanisms action.

According to the type of compensation reaction of the system in endogenous group two mechanisms can be distinguished: intensificational (increasing) and dampening (lowering).

The former is connected with the necessity of organism's activity, directed at the "increase" of separate homeostasis parameters with lowering of associated environmental parameters. In this case the activity of the system is generally accompanied by additional activity (intensification).

In the second case the system has to "work" to lower its definite parameters because of the relevant increase in environmental characteristics. For example, in case of environmental temperature lowering, the organism has to stabilize its temperature by "warming-up" – i.e. by means of blood circulation intensification. And vice versa, with the environmental temperature increase the organism "withdraws extra heat" thanks to perspiring. Both types of mechanisms are accompanied by exercising energy.

According to the direction of influence the mechanisms under consideration can be split into two groups: endogenous and exogenous. Endogenous group of mechanisms is connected with changes inside the system. Exogenous group is directed at changing the environmental parameters.

Endogenous mechanisms. Some basic directions of the realisation of endogenous mechanisms of *negative feed-back* can be distinguished.

(1) Complex usage of all system mechanisms. The given direction is connected with the reconstruction of all organism's systems to "slake" the unfavourable factors. Concerning temperature control of animals, among other factors practically all the potential of the organism is involved: blood circulation system, skin, the nervous system, secretion organs etc.

(2) Creating reserve compensational subsystems (organs). Sometimes it is more effective to involve not the whole system potential but that of some of its subsystems (organs). Many biological species follow this way. Their holistic regulation is supplemented by a special function of some organs (skin or hypodermic tissue)...

Details

For the purposes mentioned above camel accumulates resources in its humps. The majority of animals evenly spread the stock in fat accumulation. It is usually fat that plays the role of the compensation fund in case of food and water problems and cold spell.

To fulfil compensation functions such social systems as countries create special organs endowed with resources. In the majority of states such organ is called the Ministry of Extraordinary Situations (MES). There are mini MES in many firms.

No doubt, the existence of such compensative funds eases immensely the regulation of financial systems. By the way, in the USA the central organ of financial administration is called Federal Reserve System.

(3) Creation of buffer zones, which soften environmental influence. In contrast to the previous direction, the action of buffer mechanisms under study is aimed at preventing or lowering the amplitude of changes of these influencing factors rather than at compensating ("slaking") the influencing factor. Finally, any influence on the system originates from the environment. Setting out the protective barrier with the environment, the system can considerably control metabolism processes (i.e. substance, energy, information exchange with the environment). In one case it is possible to prevent the flow of harmful substances into the system, in the other – to soften energy effect (to lower temperature drop in particular), in the third case it is possible to protect the system from harmful information influence that can ruin or injure information structure of the system.

It should be emphasized that we are dealing with the protective barrier inside the system, though it is the one place on the periphery. Our planet (some layers of atmosphere), its hard nucleus (soil), living organisms (skin), firms (commercial secrets protection, resources quality entrance control), countries (outside expansion protection) have the same kinds of barriers.

Details

With vertebrates skin acts as protective layer.

It is skin that protects the body from the environmental influence and fulfils some functions: *protective* (it protects the body against mechanical influence and injuries, penetration of dif-

ferent substances and microorganisms), *secretory* (it accounts for secretion of water and different products of metabolism), *sensory* (thanks to a great number of nerve ending in skin), and with higher animals – *thermostatic*. To ease the latter, during the years of evolution, optional means such as hypodermic fat or thickened corneous layer (birds' feathers, mammals' hair) that undergoes regular change have developed. (Biological, 1989).

The human beings have advanced in this respect having gained clothes that fulfil the function of a protective layer, allowing adaptable transformations to happen.

We should focus our attention on the fact that claws, horns, shells and beaks are part of skin. These are means of active protection from the environment. Inquisitive readers can try to analyse analogues of all protective functions with reference to a firm and a country.

Exogenous mechanisms. The group of mechanisms under discussion is aimed at correction of environmental conditions. In the given case the system influences the environment for the purpose of metabolism improvement. Some basic directions of the realization of exogenous mechanisms of negative feed-back can be distinguished.

(1) Creation of buffer zones. The group of mechanisms under discussion is an analogue of the mechanisms of forming similar zones in the system. In this case isolation barriers are formed by the system in the environment. As the instrument of realization of the given kind of mechanisms we can name the ones created by human beings to prevent direct contacts with harmful environmental factors.

Details

The simplest example of such protection is an ordinary mechanical barrier: on the perimeter (fence) or on the size (premises). They can protect from animals (antimosquito net), rain, temperature (premises or special barriers), water (dam or draining facilities, equipment) etc. Barriers protecting from different kinds of influence (light, thermal, noise, electromagnetic, chemical, biological (antiinfectious including), information etc.) are to be treated separately. A lot of animals use similar instruments (recall birds' and insects' nests, beavers' weirs and many other things).

Sometimes the borderline between endogenous and exogenous buffer mechanisms is rather conventional. Can we consider different kinds of clothes exogenous barrier? Strictly speaking, yes. They have become a harmonious article, inseparable from humans. Luckily, protective masks and diving-suits have not yet become such. Light-protective caps, gloves, glasses, kinds of footwear, lubricants, covering etc. refer to this group of protective instruments.

The following things form separate subgroups:

- means protecting from *information* influence;
- information protection means. This is not the same.

Means protecting from information influence imply protection from any kind of influence (more often it is information influence) that can destroy the information code of system organization. For social systems it is information aggression that disrupts or distorts the order (traditions, discipline) of system's functioning. For biological systems it is viruses that cause such influence. Invading a cell, they destroy information programme sustaining homeostasis of the organism, they cause consequences called disease. This is akin to viral "infection" of computers with kindred consequences.

Any instruments can be used as a means protecting from information influence: mechanical, physical, chemical etc. Let us recall frontier barriers for imported literature, artificial radio interference (jam inimical radio stations) or antiviral medical bandages.

Information protection means, on the contrary, use information as a means protecting from different kinds of influence. Most often such protection is based on using instruments of frightening off or estrangement. With animals it can be marks or frightening off signals, emitted in the environment. With human beings different kinds of weapon, any forms of force demonstration fulfil such functions. Cultural and social-psychological barriers that prevent penetration of alien culture and ideology perform the same role.

(2) *Metabolic flows processing.* The given group of mechanisms is used for adaptation of metabolic substance, energy, information flows, with the aim of bringing them to optimal parameters. Two basic directions can be distinguished:

treatment of flows proceeding from the environment into the system. The aim is to obtain maximum approximation of their characteristics to the homeostasis parameters;

processing flows directions from the environment into the system (system wastes). The objective is to approximate the system to optimal environmental parameters.

Often usage of mechanisms of the group under discussion is carried out alongside with employing instruments of the previous group. In some cases it represents the version of the latter.

Details

The simplest examples of using instruments of the first type are different sieves, nets, filters. In industry the functions of the prior processing of substance-energy flows can be fulfilled by the most complicated technological systems (raw material enrichment, water and air treatment). In society, as a rule, either information handling or its purposeful correction is applied.

Reverse flows (from system into the environment) processing is of primary importance. This fulfils two basic functions. First, it protects the system from the unfavourable difference of its parameters. The fact is the environment that is external in reference to the system is in itself a system that has its own homeostasis parameters. Their deviation from optimal characteristics can shake or seriously break the so called *bearing capacity*. The latter characterizes the system capacity to sustain the level of homeostasis, wherein it is capable of fulfilling its vital functions, including reproduction of resource base and performing the processes of reconstruction of environmental parameters quality. Second, very often processing of flows, proceeding from the environment, turns into treatment of the ones which enter it. The intake is achieved in the environment.

(3) *Conditioning.* Mechanisms of this group centre on environment transformation, immediately adjacent to the system. These areas of space are usually arbitrarily called local. System influence is directed at creation of conditions that are most favourable for homeostasis maintenance and increase of metabolism processes efficiency. As a rule conditioning is possible on the basis of the two groups of mechanisms discussed above or arises from them.

Details

In particular, if relative isolation of the space adjacent to the system is provided, optimum conditions can either be maintained on their own or formed under the influence of nature force. So, for the most part of the year dwelling apartments do not need heating. While for making dams beavers need to build a dyke only.

Human beings have mastered conditioning perfectly. Man-made apartments as well as industrial environment have expanded over the whole planet and even spread in the open space outside it. People have been living and working here for over two centuries already.

Conditioning included a wide range of functions directed at change or conservation of any environment features (physical, chemical, informational) (for details refer to: Melnik, 2001). It is linked not only to the influence on physic-chemical parameters (temperature, pressure, humidity, chemical characteristics) – this is what comes into the head first. The instruments under discussion are linked to landscape changes or exposure of conditions for communication (road, bridge, canal building etc.).

(4) *Spatial migration.* This kind of mechanisms is based on usage of the factor of spatial heterogeneity of the environment. Instead of changing local environmental conditions, sometimes it is more useful to transfer to the space spheres with more favourable conditions for system functioning.

Details

Animals migrate in search of more favourable resources when the previously inhabited areas are used up. These mechanisms are widely used by human beings; this is how extractive branches of industry “migrate”. Fishing and cattle-breeding are based on this. Actors’ tours are based on a similar principle. Many people migrate looking for jobs. Of course, workers’ activity in supply and sales sphere of many firms is connected with it.

(5) Seasonal recurrence, or in time migration. If the previous mechanism is based on the spatial heterogeneity of the environment, then the one considered concerns temporal variations. The matter is that within the unchangeable spatial natural habitat the system uses cyclic temporal variability of environmental conditions. In other words, the system chooses the most favourable time intervals of metabolism processes activation.

Details

Theoretically all plants and animals use the given group of mechanisms. All living cycles are synchronized according to daily or yearly cycles. Nature sees to the use of environmental heterogeneity in time. In this respect we can name night hunting of animals, seasonal plants vegetation, fishes and birds seasonal migration, changes of insects’ activity with different weather conditions and many other things.

Mechanisms under discussion are widely used in human activity. Seasonal jobs are most pronounced in agriculture, forestry, building, recreation. We undertake attempts to use maximum of time factor while ascertaining summer and winter time. Many kinds of services set more favourable working hours, reasoning from temporal possibilities for getting services. Within 24 hours even money changes spheres of its usage, finding more profitable money turnover cycles. There is a term “night money”. It denotes the money flows that migrate all over the planet in the night time.

(6) Spatial-temporal migration. This kind of mechanisms refers to the combination of the two previously mentioned directions, when the system migrates both in time and space. Birds’ migration is the example of this kind. In economics it is seasonal capital, workers’ migration.

Details

Space migration fulfils double function. Previously we focused our attention on system migration *looking for favourable life-span* conditions. We can treat this group of mechanisms differently considering them as a means of protection from unfavourable factors. At every moment system’s coordination in time and space is an integral condition of its successful functioning in this world.

Triumphs and failures in sport single combats is the best illustration of offensive and protective migration mechanisms’ effectiveness in time and space. Economists have formulated migration effectiveness as “*a thing wanted at necessary time in a necessary place!*”

(7) Cooperation with other systems. One of the perspectives that the system can use while optimizing it extend existence conditions is its integration with other systems. In fact, in this situation utilization attempt (i.e. beneficial use) of dissipative activity, which is inevitably related to system’s existence, is realized. *Energy dissipation* is a reverse and useless dissipation into the environment. It can occur as immediate loss of heat and other kinds of energy, or it can be lost with material wastes disposal of the activity. Both can be useful when systems cooperate. A system’s wastes can be valuable raw material for another system. We make certain that it is easier for some people to get warm together. Besides, cooperation provides side benefit (energy economy) when realizing vital activity. Ecosystems are based on the principle of cooperation, that reduces homeostasis maintenance and gives the system tangible energy saving. In millions years of evolution nature has worked out and polished a diversity of ecological cooperation forms (table 1) with

its merits and demerits which they carry to every species. Mutual benefit is the motive power of synergism in nature.

Details

Symbiosis is one of the most favourable forms of cooperation of biological species that contributes to saving energy on adaptation for environmental conditions. In symbiotic systems one of the partners (or both) superimposes the problem of its feed-back regulation with the environment. Different links can be the basis for the rise of symbiosis. These are trophic links (nourishment of one of the partners at the cost of another by unused food remnants, digestion products and its tissues), spatial (settling on the surface or inside of another body, common use of houses, holes, shells etc.). As a result of symbiosis one of the partners or both acquire a gain possibility while fighting for existence. (Biological, 1989).

Something of the kind happens in *economy* when smaller firms, reducing their lives, make a living by being around big ones. This cooperation is beneficial for the latter as well. Big firms do not fulfil petty (or very often “dirty”) work. In Table 1 characteristics of other cooperation forms are given. It would be useful if readers tried to extrapolate the data given in the table on the conditions of *economic system* by understanding proper parallels and differences.

Table 1

Types of relations between individuals of different biological species (Korsak, 1998)

Types of interrelations	Signs of interinfluence	General characteristic of interrelations
1 Mutualism (interaction)	+ +	Both species benefit, interrelation is necessary for both or for one only
2 Commensalism (boarding)	+ 0	1 st species benefits significantly (+), the 2 nd has neutral relationships
3 Parasitism and preying on others	+ – (at a level of individual) + (at a level of species)	Individuals of the 1 st species (beasts or parasites) benefit from the contact; individuals of the 2 nd species (victims or masters) suffer from it. Benefit for the second is realized at a level of the species as a whole
4 Neutralism	0 0	Both species exist independently, without any significant impact on each other
5 Amensalism	0 –	The 1 st species causes damage for the 2 nd one without any immediate benefits and significant negative reaction
6 Competition	– (+) (+) indirectly indirectly	Generally we bear in mind uncompromising fight for resources, when both species “forces” are equal and both get damaged. It may turn out beneficial from the point of view of selection and functional differentiation

3. Mechanisms of positive feed-back

Stationary system can maintain the state of its dynamic equilibrium only at the cost of its using the produced free energy. However, what will happen if the dynamic equilibrium is disrupted. There may be two reasons for this: a) changes in the system itself (it becomes weaker or stronger); b) changes in the environment (it becomes less favourable / more favourable for homeostasis maintenance).

For the system itself these reasons are difficult to distinguish, because they lead to the same result that can be formalized as “system resources’ inconsistency to environmental conditions”. In other words, the system cannot maintain the state of its dynamic equilibrium (homeostasis) under the present environmental conditions. Two different situations can occur.

1. *Free energy is not enough* to “put out” environmental influence. (Environment is perceived as “excessively violent”).

2. *Energy excess accumulates inside the system*. The system “does not have a chance” to lay out for its necessities or dissipate in the environment (it is “perceived” as “too favourable”).

Details

We will recall one more time on the relativity of the notion “favourable/unfavourable environment”. Under the principle of optimum, the most favourable range of environment parameters is the one that maximum approaches the optimum “gold middle”. It is within these optimum limits that the system confines the state of its homeostasis most easily. Any deviation is unfavourable for the system. For example, for living organisms both cold and heat, excessive aridity and redundant humidity, high and low pressure etc are equally disastrous.

It is worth bearing in mind other aspects. Environmental impropriety can be “provoked” by system’s behaviour, when because of changes in metabolism processes the state of homeostasis “shifts” a bit. July sun doesn’t warm the elderly people, and even in summer they wear valenki, while “blooming” youth does not know what to do with their forces and they wear their coats open in winter. The state of homeostasis is individual for each specific person and it can differ from the parameters of an average-statistic human being. Even for each concrete person it “goes” around “middle line” all his life. This is true for any stationary system which can “lower” or “increase” the level of its conventionally “normal” homeostasis.

Transformation of homeostasis level occurs when the system’s adaptive ability is not sufficient enough to keep up with the given environmental changes and maintain stable homeostasis level by means of the mechanisms of negative relationship. So, it is the system that has to change itself. In this case the system applies the mechanism called by the specialists “the mechanism of positive reverse relationship”. It is called positive because changes in the system occur simultaneously with the processes of environmental changes. In this respect let’s recall our reaction to the danger of losing equilibrium: we either make an attempt to hold it or lose it purposefully.

Details

As long as there is a hope to hold equilibrium, we bear it, bending in the direction opposite to the push (the mechanism of negative feed-back). If there is no hope to hold, it is better to fall controlling the situation, trying to group yourself, for example. In young sportsmen’s training programme much attention is given to the mechanism of positive feed-back as well as to the art of using the mechanism of negative feed-back. Football-players, hockey players, parachute jumpers, mountain-skiers are taught not only to hold balance but to fall property as well. Very often they start with the latter.

In case of the mechanism of *positive feed-back* being at work the system rebuilds its organization structure, changing the level of its homeostasis.

According to the changes occurring in the system homeostasis level transformation can be conventionally classified into three groups:

1. Transformations increasing homeostasis level.
2. Transformations decreasing homeostasis level.
3. Transformations imitating changes of homeostasis level.

The latter are linked not so much to the change of real homeostasis level, but to its outside manifestation. Traditionally it is connected with the realization of some protective functions of the system.

Details

Similar method is widely used in technology and is considered a protective method for the whole system. Here quazidruption of the system is caused by purposeful pulling down of special protective blocks. The disruption of one block prevents the disruption of the whole system. We can not but remember the lizard that, when losing the tail, keeps safe.

This expedient of imitation is used by many animals imitating their weakness or even death for the sake of life. Often birds divert potential enemies from their nests with nestlings.

Imitation expedients are used in economics, politics, military science, sport. The target is to blunt vigilance, deceive, win the victory over the adversaries or rivals. A widely spread expedient is “showing false modesty”. Professional cadgers strive to look even more ugly and poor countries – poorer, to get charity.

Not only homeostasis reduction but its increase can be imitated as well. Thus, many countries or firms imitate their prosperity for getting credits. Such method is swindlers’ favourite; they blunt potential victims’ vigilance by their outward prosperity.

By the reverse nature of current changes homeostasis transformations can be differentiated into two groups: *reverse* and *irreverse*.

Reverse transformations suggest a possibility of return to the previous level of homeostasis without qualitative changes in the system.

Note

In similar way many animals fall asleep in winter considerably changing homeostasis parameters in winter, easily turn back to the previous metabolism level in spring.

A lot of sectors of economy and firms that have seasonal works also practice such strategy of temporal reversible homeostasis change.

Irreverse transformations are characterized by the impossibility of coming back to the previous qualitative condition of the system. Even the attempt to return to the former homeostasis level fails. Thus, transmutation of a caterpillar into a pupa, and then into a butterfly is irreverse.

In economics such transformations are connected with the restructurization of firms and branches of industry. Return to the previous condition is impossible because of the loss of many ties that existed both inside and outside the system.

By the nature of post-transformation changes *transformation mechanisms* of the system fall into two groups:

mechanisms that do not change characteristic features of the system (*adaptation mechanisms*);

mechanisms, changing characteristic features of the system, so the previous system vanishes, transforming into its successor (or system successors) (*bifurcate mechanisms*).

The mechanisms which have been discussed touch upon the questions of system’s stability and vital activity. Knowledge of theory and practice of managing the given mechanisms provides considerable increase in efficiency of economic systems’ functioning.

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