# HUMAN CAPITAL AS THE BASIS OF INNOVATIVE DEVELOPMENT

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**In accordance with the modern theory of economic growth, the dependence of the production function over time is determined by the factors:**

$$Y(t) = F\left(K(t), L(t), T(t)\right)$$

$Y(t)$ - the flow of products produced over for a certain period of time;

$K(t)$ - physical capital;

$L(t)$ - labour;

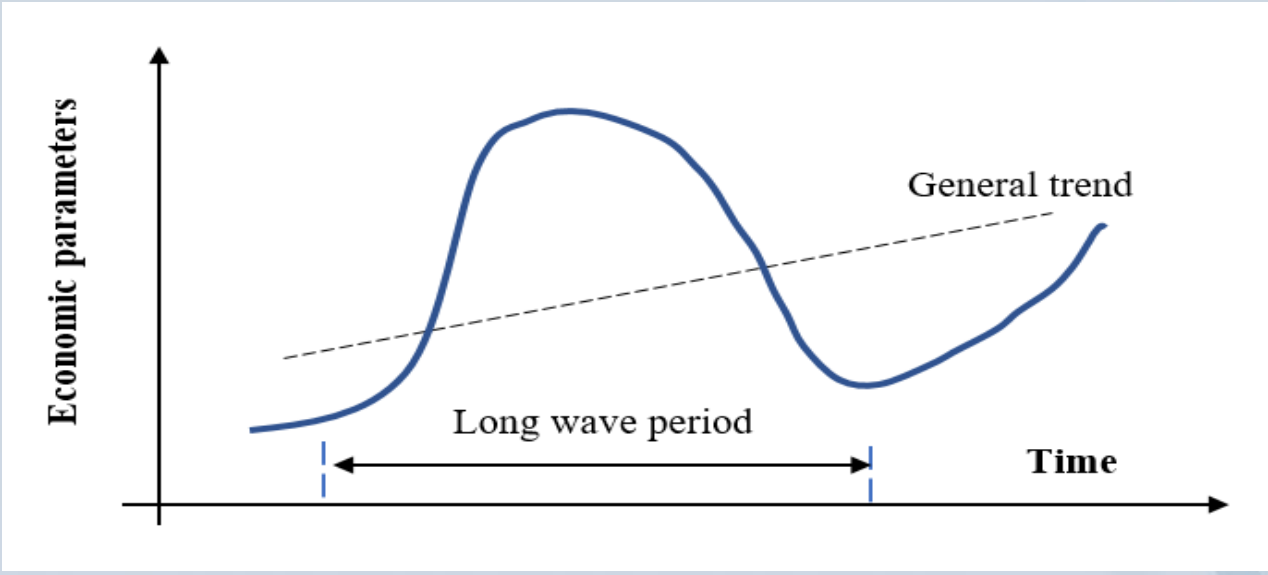
$T(t)$ - technology (level of knowledge, or human capital)

In models of economic growth, which describe the economy of marriage at ***the industrial stage***, with a designated virtual function, the main respect was given to the infusion of physical capital and practice. These models include the Leontief “Exit-release” model, the neo-Keynesian Harrod-Domar model, the Solow-Swan model of exogenous growth and others. At the same time, they mean that:

$$\frac{\partial F}{\partial K} > 0; \quad \frac{\partial^2 F}{\partial K^2} < 0; \quad \frac{\partial F}{\partial L} > 0; \quad \frac{\partial^2 F}{\partial L^2} < 0.$$

It is assumed that the technology is non-competitive in the sense that the use of its results by one firm does not deprive others of the opportunity to use it.

However, during the transition to the stage of ***post-industrial society***, knowledge, that is, human capital, begins to play a leading role in the development of the economy. Even the very transition from one stage of social development to another is determined by the spread of fundamentally new production technologies. This explains the presence of long Kondratiev waves.




One period of long Kondratiev waves

The current stage of economic development is defined as the ***knowledge economy***, and the country's competitiveness is determined by its human potential, which, in particular, finds its embodiment in innovative developments.

The purpose of this report is the synthesis of a mathematical model focused on ***the description of innovative processes using a control mechanism in the non-linear form***. This work is a continuation of the article:

***Malyarets, Lyudmyla M. et al. (2023). Innovation Development of an Enterprise: Modeling Dynamics. Business Inform 10:162–174.***

The logistic curve, which describes the economic effect of the implementation of innovations, can be determined by an ordinary differential equation of the first order:

$$\frac{dx}{dt} = \gamma\left(x - l_L\right)\left(l_U - x\right), \qquad (1)$$

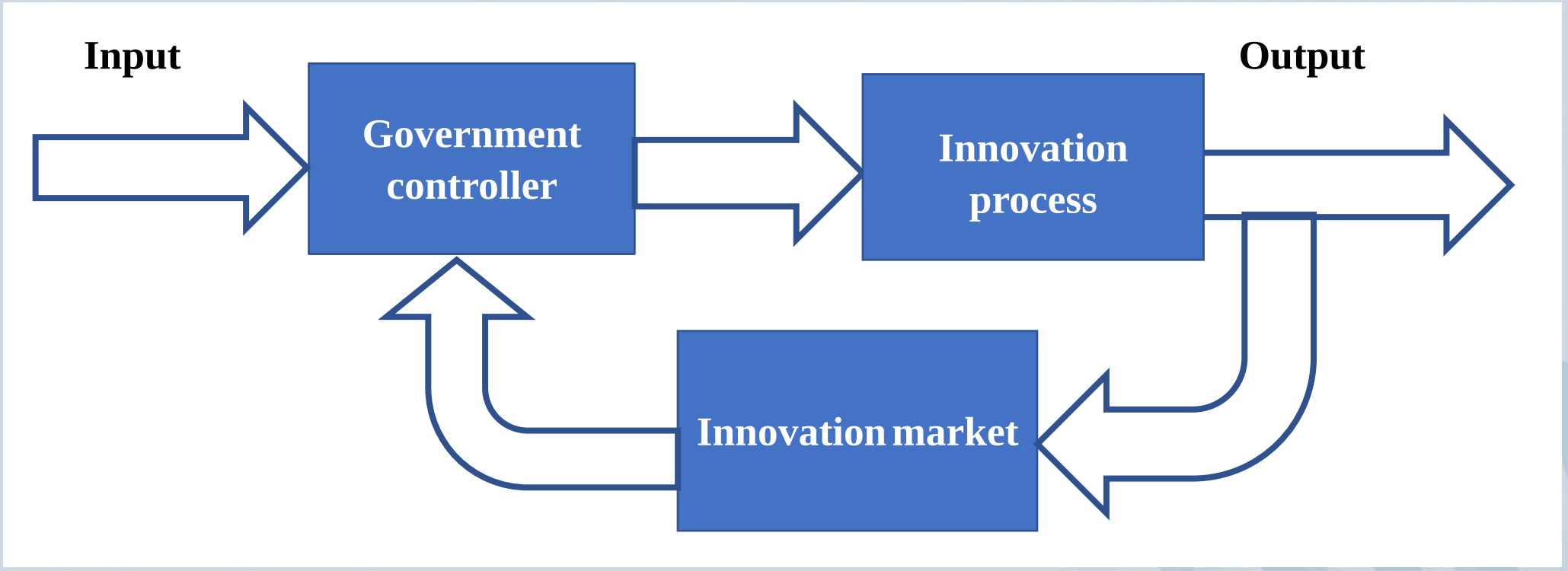
where $t$ is the time spent on the development of new technology;

$x = x(t)$ – a technologically and economically significant indicator that changes due to the introduction of innovative technology;

$\gamma\ (\gamma > 0)$ is a scale parameter, the inverse of which is the characteristic time of the transition process in the system where the innovation is introduced;

$l_L, l_U$ – the lower and upper limits limiting the possible changes of a significant indicator as a result of the implementation of innovative technology.

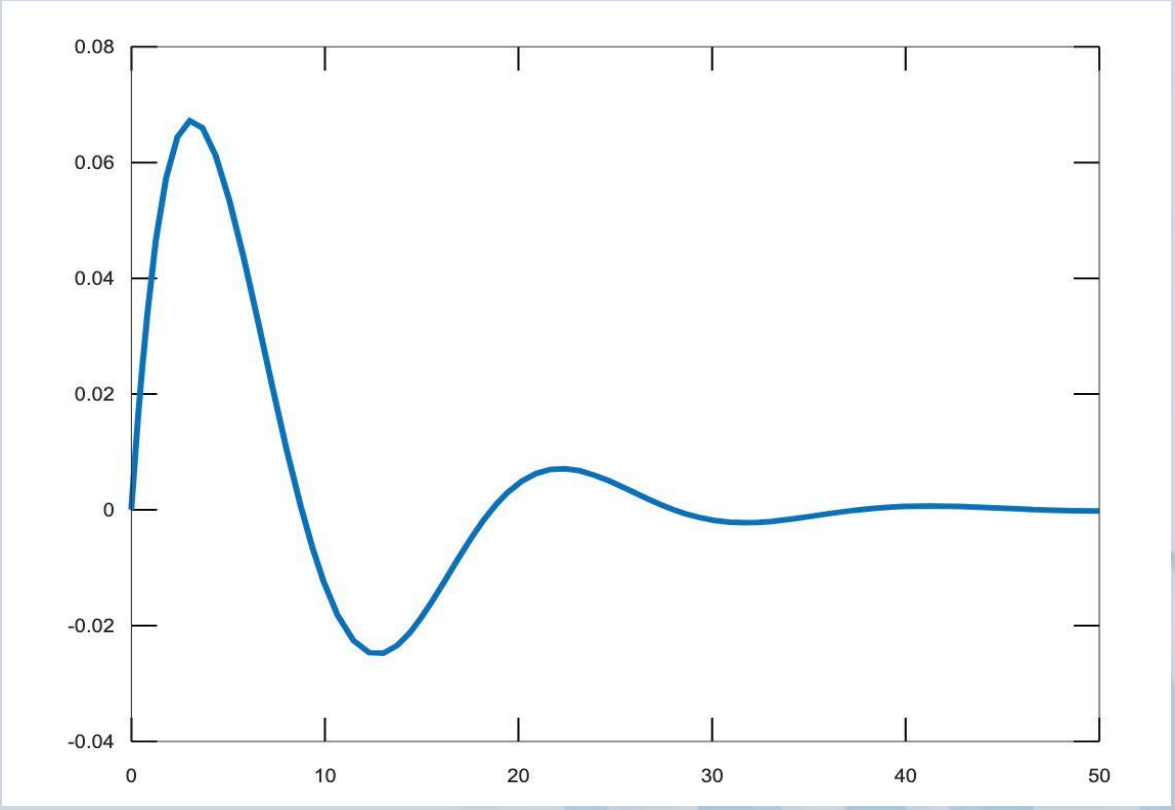
In general, the process of introducing innovations should be considered as ***a feedback system***. And this connection can be not only positive, but also negative.

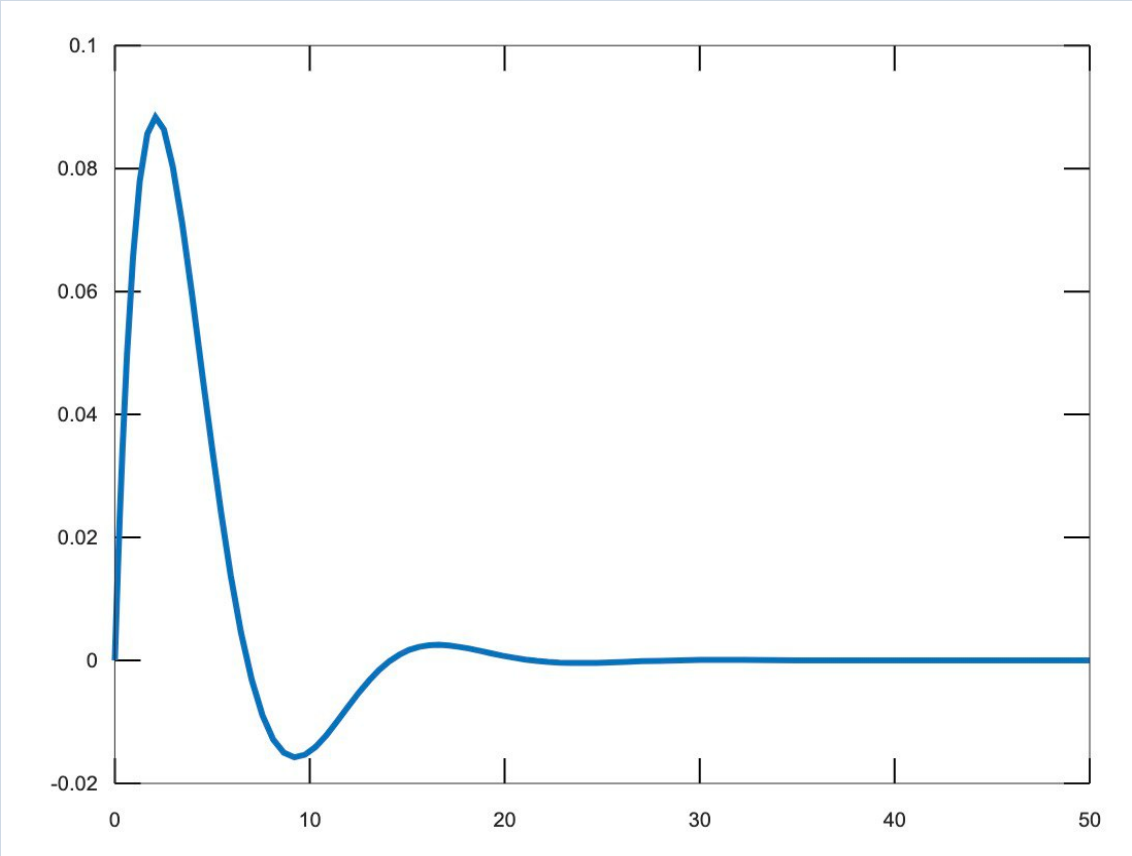



General scheme of feedback that can take place in innovation diffusion

To illustrate the possible solutions of equation (1), simulation modeling of transient processes during deviation of the system from the equilibrium state was carried out. The task was to select such parameter values that would allow modeling various transient processes.

Thus, on the cross-section of the phase trajectory of the system development, it can be seen that at least two cycles take place, the amplitude of which gradually decreases until the system returns to a state of equilibrium.






When the parameter that characterizes the inertia of the control system increases, it leads to a faster transfer of the system to a state of equilibrium. At the same time, the amplitude of the deviation from equilibrium increases significantly in the first half of the first cycle, and then the rapid growth is replaced by the same rapid decline

Critical values of the parameters were also determined, at which it becomes impossible to return the system to a state of equilibrium, i.e., a catastrophic failure of stability occurs. This breakdown occurs when the system passes the bottom point of the first oscillation cycle.

# *Conclusions*

Innovative development, effective implementation of innovations is one of the ways of capitalizing human potential, transforming it into human capital. Competition in the innovation market and various regulatory measures can be associated with sharp disequilibrium, which can lead to the collapse of the innovation market. Such a situation is especially dangerous when regulation of the investment process is carried out at the state level. Therefore, in order to ensure a stable mode of functioning of the regulated innovation process, it is necessary to apply a systemic approach and determine the parameters of the system under which certain types of bifurcation can occur in it.