

РОЗДІЛ 2

Макроекономічні механізми

Modern Approaches to the Hysteresis Analysis in Economic Systems and EU experience

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The article analyses the hysteresis methods of analysis of economic systems. The causes and consequences of hysteresis are considered. The spheres of hysteresis manifestation, their common and distinctive features are analysed. The role of the phenomenon of hysteresis in macroeconomics phenomena as well as in some other spheres of economic science has been determined. A generalizing analysis of hysteresis on the examples on micro- and macro-level its impact in various situations was conducted. The role of hysteresis on the example of cyclic phenomena in economic development is disclosed. The possibility of determining the common features of the manifestation of hysteresis in various cases on data from open sources is analysed. A comparative analysis of modern European studies in this area is conducted on the example of the some EU countries. A method of expanding the scope of hysteresis in the economy is proposed.

Keywords: development, hysteresis, macroeconomics, models.

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Introduction. Scottish physicist James Alfred Ewing (1855-1935) introduced the term hysteresis (from the Greek hysteresis – backlog, lag). In this way, he named in the 1890s discovered by him as a result of numerous experiments a new, unknown before that property of iron rods. The term hysteresis was originally used as a characteristic of a particular physical process (Hurchenkov, 2011). However hysteresis effects have been observed or postulated to exist in a wide range of non-ferromagnetic contexts ranging from soil moisture to migration flows (Cross, 2008).

Research task. The purpose of the research is to study in detail the current experience in studying the problem of the manifestation of the hysteresis effect in various situations and on various systems. Systematization of existing researches and identification of prospective directions for the further application of hysteresis in different economic systems.

Analysis of research and publications.

The use of the term “hysteresis” has its origins in natural sciences. For example, in biophysics the vibration of biological membranes may follow a hysteresis loop. The expansion

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and contraction path of arteries may also be subject to hysteresis due to interior frictions. Similar considerations can be found in nonequilibrium thermodynamics within the context of "chemical hysteresis" in the behaviour of gas and fluids (Franz, 1990).

Hysteresis models in economics have been concerned with the determination of just single endogenous variables (output, inflation) (Cross, 2008). One of the first who described in detail the phenomenon of hysteresis and made mathematical analysis of hysteresis were the Soviet scientists Mark Krasnoselskii and Alexei Pokrovskii (Krasnoselskii, 1983), whose works were subsequently used not only by physicists, but also by researchers of the social sciences. One of the first scientific research in which the phenomenon of hysteresis was implemented to describe economic phenomena was Laura Piscitelli in her Ph.D. thesis "Hysteresis in Economics" (1997). A key innovation in the thesis was to devise a means of testing for the existence of hysteresis in time series regressions designed to explain unemployment (Cross, 2011). However, scientists began to use hysteresis to describe economic problems in the 80s of the 20th century.

Hysteresis principle is applied namely in industrial economics with special reference to international trade and in labor economics with special reference to unemployment (Franz, 1990).

Rod Cross examines (Cross, 2008) four areas in which epistemological foundations of hysteresis particular referred to economic systems according to Ernst Mach vision:

1. Any "facts" depends on the classification devices or theories used, can at least explain how this is the case in economics, and indeed explain how the harder sciences are not immune from such problems (an early view on some economic phenomenon may be fundamentally inconsistent with its later scientific theory. For example, it has happened with the "unemployment").
2. A second area regards the heterogeneous representation of economic agents. The hysteresis models contain a far more complete "presentment of the facts" of heterogeneity between economic agents, deal with the aggregation problem whilst respecting the heterogeneity of economic agents, the testable implication being a selective, erasable memory
3. The representation of the memory of shocks affecting economic systems. Mainstream economic models (DSGE) contain a short-term but no long-term memory of such shocks. However, some factors can have a lasting effect. This is consistent with the memory properties of hysteresis models, but not with the no long-term memory property of mainstream models.
4. A fourth area of note is the consistency of the Machian view with the practice, if not the preaching, of economics regarding "stylised facts". In the preaching of mainstream economics the "facts" that should be used to test the implications of economic theories are the raw data, over or across time (economists often use consistency or inconsistency with stylised facts as evidential grounds for supporting or criticising theories).

Hysteresis generally refers to a situation in which there is a permanent change in a quantity that is triggered by some other variable which has changed only temporarily. Thus, the causal effect remains although the initial cause has vanished. One has to distinguish between hysteresis on a micro, i.e. firm level and an aggregated macroeconomic scale. There is no standard formal tests of economic hysteresis – different empirical approaches have found patterns that are in accordance with this phenomenon (Belke, 2013). Matthias Göcke named it 'weak' (microeconomic) and 'strong' (macroeconomic) hysteresis. 'Genuine' hysteresis can be

directly derived from an economic optimisation behaviour, since the different branches are based on the optimal reaction conditional on the circumstances predetermined by the past. (Göcke, 2002).

The manifestation of hysteresis on the *microeconomic level* first of all we can see in analysing the supply and demand, establishing a market equilibrium.

Typically, hysteresis in economics is based on sunk adjustment costs, which may occur on the supply side of the market (as e.g. entry or exit costs on international export markets) or on the demand side (as in the case of hiring and firing costs affecting labour demand). Learning by doing on the supply side (permanently lowering costs) or positive experience effects of consumers on the demand side (later on increasing the willingness to pay) result in path-dependent reactions (Göcke, 2015).

The role of hysteresis in economic and financial modelling is now considered. Most such models are based on representing individual economic agents as *hysterons*, an approach that provides an attractive characterization of various microeconomic scenarios such as the entry and exit of firms in a particular market (Cross, 2009).

An example of sunk entry costs analysis and the manifestation of hysteresis is shown in two recent researches. Henry Aray (Aray, 2015) shows that that decreasing *sunk entry costs* have a stronger impact on the option of entering than on the option of exiting and hysteresis is lower with decreasing sunk entry costs. For firms that enter market first, the hysteresis decreases, while it increases for the rest of the firms.

Ansgar Belke, Matthias Göcke and Martin Günther (Göcke, 2013) analysed the hysteretic impact of *real exchange rates* on German exports and they found hysteretic play effects in more than 8 % of total German exports. Hysteresis in foreign trade generally occurs if sunk market entry costs exist and on a microeconomic level hysteresis occurs via a band of inaction. Authors showed that not every increase or decrease of the exchange rate will, automatically, lead to positive or negative reactions of the volume of exports. However, a large appreciation of the euro means passing the border of a play/inaction area and results in a strong reaction of exports.

Another one example of hysteresis on microlevel was shown by analysing the prices influenced via *antitrust enforcement*. Jose Manuel Ordonez-de-Haro and his colleagues (Ordonez-de-Haro, 2014) indicate that antitrust intervention in Spain had a limited effectiveness in remedying the effects of those sanctioned practices and had an unintended effect on the price dynamics in the markets directly concerned. The prosecution of those associations resulted in a price drop only in some of the industries concerned, but not enough to improve consumer welfare. In fact, prices were generally kept above those that would have arisen in the absence of that recommendation.

In two other papers, we can see examples of hysteresis in some *goods markets* (hog production and coffee). Real options (investments in a dynamic and stochastic environment) help to understand why structural adjustment processes in German hog production take place rather slowly (Hinrichs, 2008). Results of this research draw the attention to sunk costs and uncertainty. Hog production only responds in a very limited way to price fluctuations in the pork market and the volume of production does not vary over time. From other example, Aashish Mehta and Jean-Paul Chavas (Mehta, 2008) research that the low coffee prices experienced since the disintegration of the International Coffee Agreement (ICA) are consistent with low supply response to price information. Asymmetric price transmission at the retail level helped roasters. Retailers benefit from upstream price interventions and producers jockeying to increase market share through product differentiation will tend to

oversupply in aggregate. These appear consistent with a story of disequilibrium due to hysteresis.

The manifestation of hysteresis on the *macroeconomic level* can be analysed due technology and innovations, financial markets, monetary and fiscal policy, investments, growth and crises, input-output.

Annabelle Mourougane in her research (Mourougane, 2017) underline that hysteresis amplifies the effect of *financial crises* on potential output. She argues that hysteresis has a non-trivial effect and needs to be explicitly and fully accounted for in policymaking decisions. Ignoring this effect could lead to a sizeable over-estimation of the magnitude of the output gap and to misjudgment on the current economic situation, inflation pressures, and fiscal stances.

Paolo Colla and Filomena Garcia (Colla, 2016) showed the *value of the technologies* evolves stochastically, reflecting innovation or shifts in preferences. Forward-looking players form expectations about future players' behaviour and coordinate via the signals that they receive about the value of the technology. Authors' analysis of the unique equilibrium allows to conclude that technology adoption exhibits path dependence and lock-in is not to be expected because of hysteresis effects.

The greatest spread of the hysteresis concept in the economy was in the problem of the *unemployment* (Stiassny, 1998; and many others).

Ron Martin (Martin, 2012) suggested that the *concept of resilience* might usefully be linked to that of hysteresis, which is the notion that economists tend to use to judge the impact of shocks on an economy's growth path. The idea of hysteresis is useful because, in contrast to resilience, as usually defined, it focuses not on the preservation of system functioning and performance in the presence of exogenous change and disturbances, but on how such changes and disturbances can shift system functioning and performance, and whether such a shift is negative or positive in nature and outcome.

Avinash Dixit (Dixit, 1989) argued that the ongoing uncertainty is a much more potent generator of hysteresis than sunk costs alone. He highlighted two distinct aspects of hysteresis:

- (i) very large deviations of the exchange rate from the normal are needed to alter the numbers of foreign firms and the extent of import penetration.
- (ii) Once such a change in import share has occurred, even larger deviations of the exchange rate in the other direction are necessary to restore the former condition.

Emiliano Libman (Libman, 2018) demonstrate that real *exchange rates* are often 'disconnected' from fundamentals. He showed that including endogenous norms in wage and price setting in an open economy set-up could lead to hysteresis in the real exchange rate. For a given set of fundamentals, the real exchange rate may settle down at different equilibria and exchange rate policies are not necessarily neutral in the long-run. From other side, on emerging markets can be seen another example of hysteresis effect through the deposit *dollarization* equilibrium (Krupkina, 2017). Authors have applied a modelling set-up developed to capture the hysteresis effect in dollarization for a panel of emerging markets. Two factors are usually considered to be triggers of the hysteresis effect. The first of these is network externalities. Network externalities exist if economic agents are more willing to use foreign currency if it is already widespread within the country. In this case, if dollarization has reached a high level in the course of depreciation of the national currency, it will not fall back during stabilization because use of the foreign currency has already taken root in the national economy and is no longer associated with additional costs. The second reason for the occurrence of hysteresis is depreciation expectations. In particular, the expected depreciation

of the national currency makes foreign currency more attractive even if the current exchange rate is fairly stable.

Noemi Schmitt, Jan Tuinstra, Frank Westerhoff (Schmitt, 2017) and Philipp Engler, Juha Tervala (Engler, 2018) found out hysteresis effect in *tax systems and fiscal policy*. Due to N. Schmitt and her co-authors even very small changes in the profit tax rate may cause substantial jumps in tax revenues, leading to either much higher or much lower tax revenues. Due to the coexistence of attractors, a return to the previous profit tax rate does not necessarily mean that the previous tax revenue can be realized again. At the same time P. Engler and his colleague show that the fiscal output multiplier is much larger in the presence of hysteresis and that the welfare multiplier of fiscal policy – the consumption equivalent change in welfare for one dollar change in public spending—is positive (negative) in the presence (absence) of hysteresis. So, they also said that hysteresis implies that the damage of fiscal consolidation is not limited to the short term because of its substantial medium- and long-term effects.

In *monetary policy* Daniel Kienzler and Kai D. Schmid (Kienzler, 2014) the hysteresis in potential output bears important implications for the conduct of monetary policy and that ignoring hysteresis effects may be costly. Authors examine the implications of hysteresis for the conduct of monetary policy with respect to stability and welfare considerations.

In addition, possible hysteresis effect was described in *pricing models of portfolio-choice problem* so that classic CAPMs are subject to wide hysteresis-band violations when conditionally expected returns follow a stochastic, mean reverting process (Delgado, 2015).

Investment hysteresis and potential output were investigated in (Bassi, 2016). The economy is characterized by a particular form of path dependency, “genuine hysteresis”: the most important temporary shocks affect potential output permanently.

Some researchers pay attention to hysteresis and development of *entrepreneurship*. In (Congregado, 2012) authors argue for the use of much longer time horizons in formal evaluation exercises than the few years which are commonly used to gauge entrepreneurship policy impacts (for Spain). In (Gherhes, 2017) described the influence of institutional hysteresis at the local level, which occurs when institutions are self-reproducing and changing slowly over time on entrepreneurship. The article argues that the rigidity and reproduction of informal institutions continues to stymie economic resilience and growth. Also in (Tubadji, 2016) described cultural hysteresis (individual and local cultural relativity which are together responsible for local disparities). The hysteresis effect in entrepreneurship is predominantly determined by an important, relatively resilient factor existing both at an individual, meso and at a local level, viz. cultural capital. It may occur in any period of time, older generations are more vulnerable to cultural hysteresis and female entrepreneurs seem more risk-taking and entrepreneurially inclined.

Results, conclusions and further discussions. As we see, the theory of hysteresis has become widespread in economic research since the 80s of the 20th century. For several decades scientists have been using it in the study of various economic and mathematical problems. In recent years, there has been a tendency to spread hysteresis analyses in the adjacent economic directions, in addition to the traditional problem of unemployment, economic growth and macroeconomics in general. In particular, hysteresis has found its reflection in problems of investment, entrepreneurship, marketing, fiscal and monetary policy. Its manifestations are increasingly founded in various aspects of economic research. In our opinion, it is very prospective to study the influence of hysteresis on various business processes, on individual firms and industries, as well as on the study of the peculiarities of hysteresis manifestation under

certain conditions that were not previously studied in detail: under conditions of high inflation, high volatility of exchange rates and so on.

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**Сучасні підходи до аналізу гістерезису
в економічних системах та досвід ЄС**

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У статті аналізуються методи аналізу гістерезису в економічних системах. Розглянуто причини та наслідки гістерезису. Проаналізовано сфери прояву гістерезису, їх спільні та відмінні риси. Визначено роль явища гістерезису в макроекономічних явищах, а також в деяких інших сферах економічної науки. Проведено узагальнений аналіз гістерезису на прикладах мікро- і макrorівня його впливу в різних ситуаціях. Розкрито роль гістерезису на прикладі циклічних явищ в економічному розвитку. Проаналізовано можливість визначення спільних рис прояву гістерезису в різних випадках на даних з відкритих джерел. Проведено порівняльний аналіз сучасних європейських досліджень в цій області на прикладі деяких країн ЄС. Запропоновано метод розширення застосування гістерезису в економіці.

Ключові слова: гістерезис, макроекономіка, модель, розвиток.

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**Современные подходы к анализу гистерезиса
в экономических системах и опыт ЕС**

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В статье анализируются методы анализа гистерезиса в экономических системах. Рассмотрены причины и последствия гистерезиса. Проанализированы сферы проявления гистерезиса, их общие и отличительные черты. Определена роль явления гистерезиса в макроэкономических явлениях, а также в некоторых других сферах экономической науки. Проведен обобщенный анализ гистерезиса на примерах микро- и макроуровня его воздействия в различных ситуациях. Раскрыта роль гистерезиса на примере циклических явлений в экономическом развитии. Проанализирована возможность определения общих черт проявления гистерезиса в различных случаях на данных из открытых источников. Проведён сравнительный анализ современных европейских исследований в этой области на примере некоторых стран ЕС. Предложен метод расширения применения гистерезиса в экономике.

Ключевые слова: гистерезис, макроэкономика, модель, развитие.

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