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KULTIVÁCIA EKONOMICKEJ IMAGINÁCIE EXPERIMENTOVANÍM VO VIRTUÁLNYCH LABORATÓRIÁCH (Demonštrácia na prípade Cournotovho duopolu, keď sa hráči správajú adaptívne)¹

***Abstract:** Development of global knowledge society accompanied by crises in national economies, as well as by the world economic crisis makes the economics science face new challenges. These challenges are in the first place those new phenomena and processes that may be pertinently described with the attribute of “all-round”. In this new situation it is impossible to rely purely on conventional approaches. Instead, it is necessary to search for tools that are capable of raising economic imagination to a higher level. These methods and tools also include advanced ICT and in particular applied informatics and computation intelligence products. By means of them, we can construct virtual laboratories and experiment in them in order to find hidden qualitative properties of mental models, which are created by economists beyond the economic reality. For the purposes pursued in the present study, we have decided to use the mental model which was designed and developed into its mathematical form by A. A. Cournot by the end of the first half of the 19th century. We have supplemented this model with the change in players’ behaviour in the sense that the players behave in an adaptive way, i.e. flexibly. This kind of modification of the classic duopoly is most suitable for demonstrating the phenomenon that even quite simple mental models may contain latent, at first sight unsuspected complexities. As a result, we have to be even more careful when dealing with more complex mental models constructed beyond the present-day economic reality. The investigation of a modified Cournot type of model populated with a pair of adaptive players poses relatively high demands on an analyst’s mathematical skills despite its seeming simplicity. Moreover, nor a highly sophisticated mathematical analysis renders such obvious results, which would display adequately clearly and exhaustively specific properties of this kind of model. On the other hand, to achieve a sound understanding of market processes this kind of knowledge is very significant as well as relevant and useful. Given the contemporary high standard of information sciences and software engineering, or when we have at disposal advanced products of computation intelligence (CI), there are reasonable possibilities for experimenting in virtual laboratories, which do not place high demands on more extensive preliminary skills for this activity at a PC. Potential means that enable us to construct*

¹ Autor ďakuje anonymným recenzentom za podnetné pripomienky a návrhy, za finálnu verziu state však preberá zodpovednosť sám.

virtual laboratories for tasks of this type, including also the Cournot model, include the following programs: STELLA, Vensim, SWARM Simulink in MATLAB, and some other. In the present case we have used iDmc program, which was designed in the programming language of LUA, and it runs in JAVA environment. The program is advantageous for most economists as it is freely accessible and downloadable from the Internet, and its author provides also free-of-charge detailed instructions how to experiment with it to economists, who, apart from their knowledge of economics, may not have parallel informatics knowledge and skills needed for these programming activities. The aim of the present paper is to familiarise the reader of the Economic Review with possibilities of unconventional acquiring of economic knowledge by these methods, namely on the instance of the well-known Cournot duopoly model, when players behave in an adaptive way (flexibly) rather than responding by adjustment as Cournot supposed.

Keywords: *border-collision bifurcations, closed invariant curves, Cournot duopoly and adaptive behaviour, focus, isoelastic demand function, local and global bifurcations, local and global crises, Neimark-Hopf and Neimark-Sacker bifurcations, node, multistability, saddle*

JEL: C 15, C 62, D 24, D 43

Úvod

Zvláštny, kostrbatý vývoj mnohých národných ekonomík, ako aj svetovej ekonomiky ako celku je v dnešnej dobe pre ekonómov z rôznych uhlov ich pohľadu v každom takom prípade veľkou výzvou. Príčiny nových a veľmi komplikovaných javov sú mnohoraké, ale väčšinou tak či onak súvisia jednak so vstupom ľudstva do globálnej vedomostnej éry akcelerovanej prudkým rozvojom IKT, a na druhej strane, avšak nie izolovane, od prvej príčiny, je to nedokonalá, ba priam chybná konštrukcia menovitých monetárnych² a fiškálnych systémov, ktoré generujú zárodoky bifurkácií, vedúce ekonomiky na hranu alebo aj priamo do deterministického chaosu viacerých typov. Úlohu komplikuje aj to, že do deja vstupujú ďalšie premenné, ktoré nevieme presne identifikovať, takže si treba vypomôcť tak, že sa považujú za náhodné udalosti. Touto komplikáciou sa však v tejto stati nebudeme zaberat', pretože náš cieľ je skromnejší a zameriavame sa iba na demonštráciu toho, že aj na pohľad jednoduché mentálne modely môžu vykazovať pomerne komplexné modusy správania. Pre uvedený účel sme sa rozhodli použiť mentálny model, ktorý koncom prvej polovice 19. storočia vytvoril a sformuloval do matematickej podoby A. A. Cournot. Doplňili sme ho o zmenu správania sa hráčov tak, že sa v modifikovanej verzii správajú adaptívne. Takáto úprava klasického modelu duopolu sa dobre hodí

² V danej súvislosti možno uviesť typický prípad chybnej konštrukcie, a to prípad zavedenia monetárnej únie v podobe spoločnej meny pre ekonomicky nerovnako rozvinuté členské krajiny EÚ. Tento politický voluntaristický akt založil zárodoky pre viaceré vopred nepredvídané poruchové režimy, ktoré majú potenciú generovať sklony k autoliquidácii celého tohto nevydareného monetárneho systému.