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ECONOMIC SCIENCES: ON THE AUTOBAHN, OR ON THE ROAD TO NOWHERE?

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A b s t r a c t. Model building is a fundamental activity in economic science. Addressing the complexities of representing the "real world" has resulted in significant methodological advances, which in turn play an important role in furthering the field. However, what is not as well appreciated is that there is another type of modeling involved in this activity. While the econometric models are explicitly presented and open for inspection, the other model, called the "mental model", is tacit, personal, and only rarely subjected to scrutiny. The two models are not independent; mental models define the framework within which the "public" econometric models are developed and understanding the nature of this interaction is important for the further development of economic sciences. There have are signals that the traditional approach to economic modeling is insufficient to meet the needs given current developments in understanding human behavior and policy analysis. The resistance to change has many possible causes, in this paper we briefly consider the role that mental models play in this development process and point to some alternative approaches that may be better suited to meet current modeling needs.

INTRODUCTION

Model building has been a fundamental activity in economic science since the adoption of physics-based mathematical techniques in the 1700's. Addressing the complexities and challenges of data collection, model specification, verification, and finally application has resulted in significant methodological advances, which in turn play an important role in furthering the field. However, what is not as well appreciated is that there is another type of modeling that is involved in this activity. While the econometric models are explicitly presented and open for inspection, the other model, called the "mental model", is tacit, personal, and only rarely subjected to scrutiny. The two models are not independent; mental models define the framework within which the "public" econometric models are developed.

Understanding the nature of this interaction of models is important for the further development of economic sciences. There have already been signals that the traditional approach to economic modeling is insufficient to meet the needs of current developments in understanding human behavior and policy analysis. The resistance to change has many possible causes, in this paper we briefly consider the role that mental models play in this development process and point to some alternative approaches that seem better suited to meet the modeling needs of today.

The paper is organized as follows. The next section presents a brief consideration of the function of models in general and in econometric analyses, in particular. Following this, we offer some cautionary words that these models may not be as helpful as desired, which leads into a critical perspective on models in social sciences. The role of mental models is then presented and the reality that economics is concerned with is reconsidered in light of the previous challenges. An alternative paradigm for thinking about econometrics is offered in the form of viewing reality as a complex adaptive system. The characteristics of these systems are briefly discussed and we present policy design issues that need to be considered when attempting to develop policies for this type of process. We conclude with some reflections on learning processes and challenges to implementing this perspective.

THE FUNCTION OF MODELS

Model building is a combination of theory and practice with the intent to produce simplified representations of a complex reality that still captures the essence of the phenomenon of interest. Model builders strive to achieve two objectives with their models: the ability to predict and the ability to explain. The first is associated with practice, the latter with theory. In the case of economic sciences, a case can be made that theory has become the dominant component. The relation to practice follows from the application of theoretical models to a variety of questions posed by the real world

As an example of the two perspectives on the role of modeling, Friedman [1953] and Simon [1963], clearly illustrate the two approaches [from Beinhocker 2005]:

Friedman [1953]: “The methodology of positive economics” argued that unrealistic assumptions in economic theory do not matter as long as the theories make correct predictions. If the economy behaves “as if” people were perfectly rational, then it does not really matter whether they are or not. Assumptions do not require any more justification as long as the model works.

Simon [1963]: “Problems of methodology – Discussion” counter-argued that the purpose of scientific theories is not to make predictions, but to explain things. Predictions are then tests of whether the explanations are correct. The entire logical chain of explanation needs to be tested, not just the conclusion at the end.

Given the ubiquitous nature of economics and its role in policy analysis, it is relevant to question how well the field performs in its model building activities. Casti [1990] compares economics with other model-based sciences on the basis of the models’ ability to predict and to explain. Prediction is defined as the ability of the model to foretell the behavior of a system given a set of model inputs. Explanation refers to the ability of the model to provide insight into system behavior in a simple and veridical manner. He claims that economic models perform poorly on both dimensions. As a reference point, Casti identified celestial mechanics as a discipline where models perform excellently on both prediction and explanation.

SIGNS OF TROUBLE?

Despite the preeminence of the traditional neoclassical economics perspective, a number of commentators from within the field have begun to ask basic questions regarding the veracity of the models that are based on the traditional modes of economic thinking. For example [taken from Beinhocker 2005]:

Joseph Stiglitz…

“Anybody looking at these models would say that they can’t provide a good description of the modern world.”

Gregory Mankiw…

„… given the low useful output of economists, less money should go into their research, and he [Mankiw] compared them to over-subsidized dairy farmers…

Alan Greenspan…”

“We really do not know how [the economy] works… The old models just are not working.”

“A surprising problem is that a number of economists are not able to distinguish between the economic models we construct and the real world.”

While these criticisms are directed at formal econometric models, they apply equally well to the informal mental models that economists (and all others) rely upon in their work and interactions with reality. Mental models are essentially maps of reality; difficulties arise when the map becomes confused with the actual terrain.

A CRITICAL LOOK AT MODELS

The theory of models [Chung and Keisler 1990] is that branch of mathematical logic that is concerned with the relationship between a formal language and its interpretations. Translating this into terms of the “real” world, we are interested in the relationship between natural processes (in reality] and the corresponding simplifications (the formal model) that are created to understand and to manage aspects of that reality.

Since much of science is concerned with model building, we should be concerned with some of the basic issues and questions like:

What is a model?

What are the features of a good model?

How can a natural process PN be represented in a formal system SF?

What is the relationship between PN and SF?

How can we compare two models SF1 and SF2 of the same process PN?

When does similarity of two natural systems PN1 and PN2 imply that their models SF1 and SF2 are similar?

These questions relate to the relationship of the economic model to reality. But to understand the development of the formal econometric model SF, we have to recognize that the economist’s mental model exerts an unconscious, yet pervasive, influence on the questions that are asked and how they are answered. An important step in the direction of “getting back on the Autobahn” is to apply these critical questions to the mental models of the analyst. This is a process of critical inquiry that is experiencing a resurgence of interest in the social sciences.

MENTAL MODELS

In thinking about the concept of “models”, we need to be aware that there are two types of models that are under consideration. One is the formal mathematical model that is the usual output of economic thinking and theorizing. This model is very public and (usually) well documented in terms of specifying obvious assumptions needed to assure consistency.

The other model is called the “mental model”. This represents a personal map that guides individual behavior. The mental model is made up of deeply held assumptions and generalizations that influence and guide individual behavior [Senge 1990]. Mental models can be seen as the product of a reflective feedback process that tends to filter and select information that supports firmly held beliefs. The “ladder of inference” [Argyris 1990], shown as Figure 1. below, illustrates the reinforcing feedback loop that affects the development of a mental model.

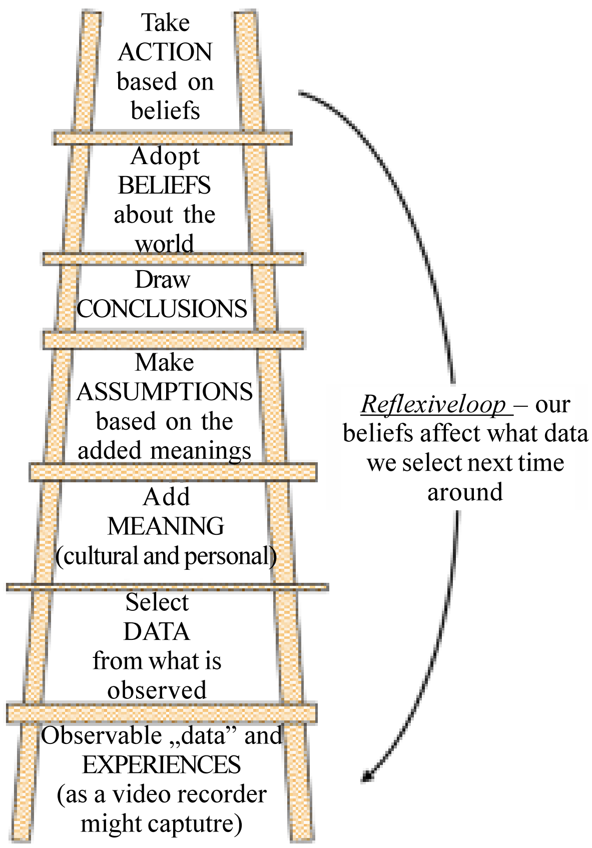

Figure 1. The ladder of Inference
Source: adapted from Ross [1994].

The relationship between explicit models and mental models is given in Figure 2. This diagram illustrates the single loop learning process. In this diagram, development of the formal model occurs in the "Choosing" phase of the loop. The inputs are empirical observations, which are subject to the biases and distortions identified in the ladder of inference, and by the effect of the mental model. In this learning process, the mental model is a type of exogenous factor; it is not affected by the on-going learning processes that utilize the formal model. However, the mental model establishes the context, or paradigm, within which the formal modeling activities are conducted. In this role, the mental model is crucially important in defining the formal model.

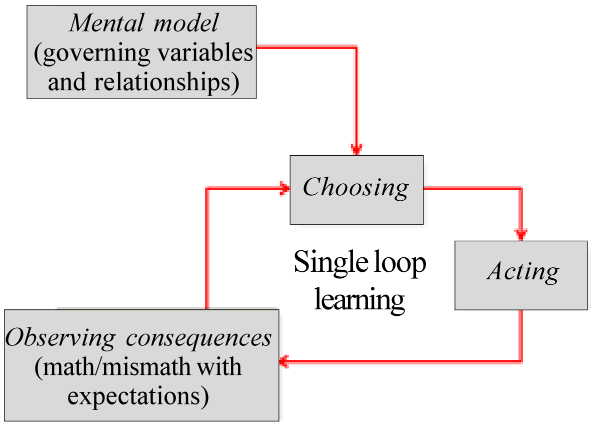

Figure 2. The single loop learning process
Source: adapted from Argyris and Schön [1978].

RECONSIDERING "REALITY"

The main purpose of model building is to impose a set of simplifications to a complex reality that allows the essence to be understood but without the extraneous details that confuse the picture. By definition, all models are wrong since they are simplifications of a vastly complex reality. However, models can still be useful if they are able to capture relevant aspects of the situation in such a way as to facilitate prediction and/or explanation. The resulting formal model is the outcome of a series of simplifications and sense-making activities on the part of the analyst. Figure 3. illustrates the relationships among successive simplifications and created understandings. At the top level, "Reality" is the complex entity that is under study. From this reality, selected "Events" are generated through empirical observations and represent the observables that are of interest in an inquiry process regarding PN. Building on the set of events, the innate human tendency to make sense of our surroundings results in these events being organized into "Patterns", which are the resulting behaviors or interactions of selected events among themselves or over time. Patterns are the basis for econometric modeling and can be employed for prediction. A significant toolbox of econometric methods has been developed to support this type of sense-making.

But at a deeper level there exist "Structures" that generate the observables in the "Real World". These structures are expressions of the formal system, SF. In the language of systems thinking, each SF is merely a hypothesis about the underlying natural process PN in the reality under study. At the lowest level, this hierarchy of insight lies the "Mental Model". The importance of these informal models is indicated by the dotted lines that point back to events, patterns, and structures. The interpretation is that the mental model influences the selection of data, the patterns of sense-making, and the development of formal models that are used for understanding and policy making. Mental models themselves are influenced by assumptions, beliefs, and the sum total of the individual's life experiences. Very often, we are not consciously aware of our mental models or the effects they have on our behavior [Senge 1990]. A central issue in this context is the degree of flexibility that an individual's mental model exhibits.

The claim of this paper is that the challenge for continued development of economic science lies in how "Reality" is perceived. This has follow-on implications for both sense-making and for model building. Despite the advances made by traditional economic theory and modeling, the earlier quotations from Stiglitz, Mankiw, and Greenspan suggest that the underlying mental models are approaching their limits of applicability in important cases. More specifically, the many assumptions that traditional economics theory is based upon are simply not as valid under current conditions as they may have been during less complex and dynamic times. Consequently, the correspondences between the formal models SF and the natural processes PN that are of current and future concern become weaker.

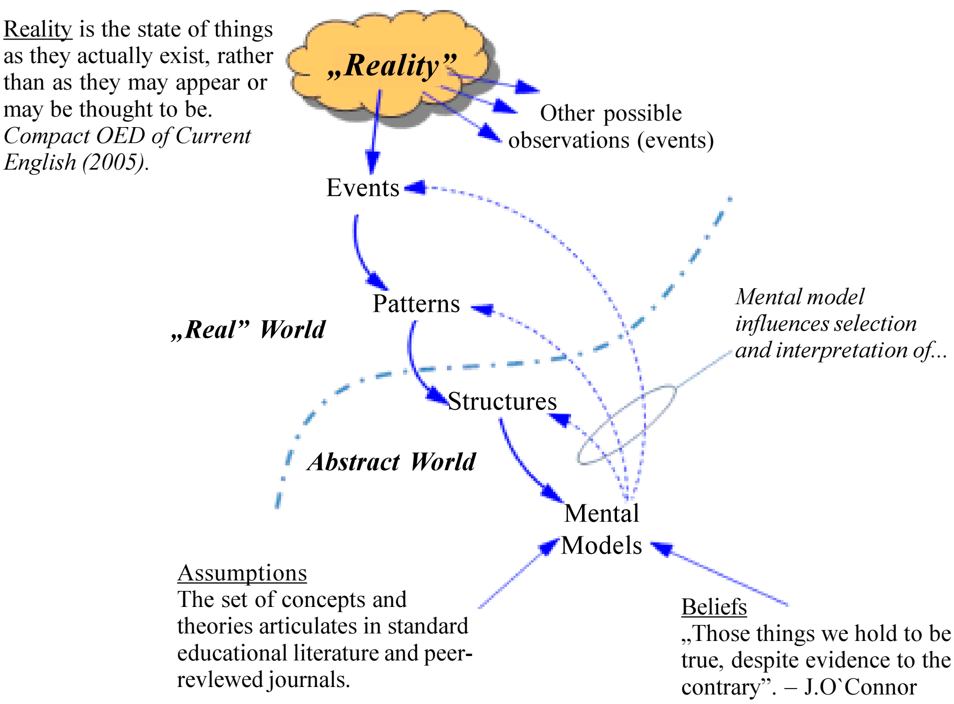

Figure 3. Level of insight
Source: own elaboration.

Some of the features of "reality" that contribute to the challenge of building useful models include the following:

Uncertainty.
Complexity (both detail and dynamic).
Adaptive behaviors.
Dynamics.
Open system, multiple nested sub-systems.
Multiple agents, multiple objectives.
Limited resource availability.
Multiple processes, multiple equilibria.

For example, in agriculture the relationship between agents in the agro-economic system is characterized by a complex set of relationships among many distinct actors. The actors can be identified as groups of stakeholders with generally similar interests within each stakeholder group, but with possibly dissimilar interests between stakeholders. The on-going relationships between stakeholder groups results in learning and adaptive behaviors among them. There will always be uncertainty surrounding many of the key factors in these relationships, with some elements being highly uncertain and possibly novel. Stakeholder groups will generally have their distinct goals that they strive to achieve. One group's actions to satisfy its objectives can adversely affect the ability of another group to achieve their objectives. Added to this difficulty is the fact that there are several different sub-systems interacting with each other as well. For example, the interactions of the legal-regulatory system, the economic market system, the fundamental ecological system, and the socio-cultural system play an important role in the evolution of industrial agriculture. There are no system-wide optimum solutions in this dynamic and evolving complex environment. Any claim of such a solution for one particular group of agents will certainly result in reactions from others that can adversely affect the entire system.

COMPLEX ADAPTIVE SYSTEMS

The basic building block of a complex adaptive system is the agent [Dooley 1997]. Depending on the system, agents can take many different forms. In economic systems, examples include buyers, sellers, producers, regulators, and other intermediaries that comprise the network of interactions that characterize the system and drive its behavior. For example, a common stakeholder analysis is an exercise in identifying relevant agents in a particular context. Agents are semi-autonomous in that they have personal goals that they seek to achieve and they also, subject to constraints, continuously scan their environment in order to build an understanding of it. Decision rules may be modified in accordance with changes in the agents' perception of their environment in order to improve the agents' fitness measure. Agent interactions induce flows of information and resources that affect the state of the overall system. Agents are embedded in multiple feedback loops that continuously affect them, inducing new actions in response to changes in the local environment. Figure 4 presents a schematic view of a complex adaptive system.

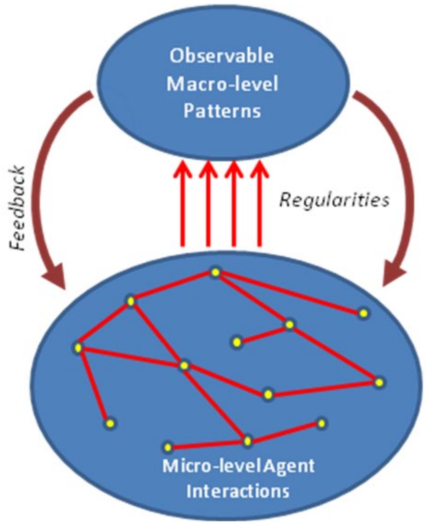

Figure 4. A schematic complex adaptive system
Source: adapted from Miller and Page [2007].

Complex adaptive systems are characterized by the following properties.

Emergence: macro-level behavior from micro-level interactions.

Co-evolution: learning and adapting to changing environmental conditions.

Sub-optimalization: perfection is not necessary for survival.

Requisite variety: more variety in a system increases resilience and strength.

Connectivity: relationships between agents are usually more important than the individual agents themselves.

Simple rules: emerging patterns of great variety can come from relatively simple governing rules.

Iteration: small changes in initial conditions can have significant effects after having passed through emergence.

Self-organization: there is no hierarchy of command and control, only a constant reorganizing to find the best fit to an environment.

Edge of chaos: systems in equilibrium do not have the internal dynamics to enable it to respond rapidly to changes in its environment.

Nestedness: systems within systems.

An interesting feature of complex adaptive systems is the concept of upward and downward causality. The observable macro-level patterns, based on events, are the result of micro-level agent interactions. This is an example of upward causality and the agent level interactions represent the natural process PN. On the basis of these observable patterns, traditional economics has then developed its formal models SF. Using these models to develop policy, the direction of causality is now downward. The intention is that policy derived from the emergent behavior will influence the micro-level agent interactions in the direction that achieves the goals of the policy. For this to have a chance of succeeding, the correspondence between SF and PN must be significant. However, since policy is based on emergent behavior, the likelihood of close correspondence cannot be assured.

POLICY DESIGN ISSUES FOR CAS

In social systems especially, change is often a specific intention of purposive human agents. Gaining insight into how the system may react to potentially significant changes should be an important factor in the design of change instruments and policies. Complex adaptive systems have unique characteristics that need to be taken into consideration, in addition to simply the objectives of the policy itself. These include the following [Ruhl 2008].

SENSITIVITY TO INITIAL CONDITIONS

Due to feedback, non-linearity and emergence, relatively small changes in starting conditions can lead to relatively large differences in overall system dynamics.

CONFLICTING CONSTRAINTS ON THE FITNESS LANDSCAPE

Changes in one system component to promote fitness may be limited by properties of other system components also designed to promote fitness.

CO-EVOLUTIONARY FITNESS LANDSCAPES

Improvements in system A's fitness prompt adaptive co-evolutionary moves in other systems that could reduce A's fitness possibilities under its new configuration, prompting yet further adaptation in system A.

IRREDUCIBILITY OF SYSTEM BEHAVIOR

Because emergence is a system-wide phenomenon, system behavior cannot be understood and designed by studying a single agent or group of agents

IRREVERSIBILITY OF SYSTEM STATES

Because the present system is a product of all information that has flowed through the system to that point in all past states, the system dynamics cannot be reversed to past states, but only steered into new directions that approximate where the past might have led if different decisions had been taken.

IMPERMANENTLY OPTIMIZABLE FITNESS

Because of co-evolutionary fitness landscape effects, superior fitness cannot be ”locked in” permanently and attempts to do so might be counterproductive.

UNPREDICTABLE FUTURE STATES

Taking all of the complex adaptive system properties into account, the future states and ”big” events of a system are not predictable over relevant time horizons.

Meadows [1999] proposed a ranking of systems-based initiatives for effecting change in complex systems. The listing is based on the notion of "leverage," which is similar to the idea of using mechanical leverage to amplify an input force. Systems have often been observed to respond to change in unexpected ways – resistance to changes, unintended consequences, and counter-intuitive behaviors being the more common examples. It has also been observed that "systems" can be relatively insensitive to certain types of interventions (similar to price inelasticity), yet remarkably sensitive to others. These effects can be seen as responses to leveraged inputs to the system. The key management skill is to be able to find the "high leverage" points in the system. Computational approaches can support this effort [Sterman 2000; Epstein 2006].

The leverage effect increases down the list. However, it also becomes more difficult to implement policies as their effect increases. Not surprisingly, the most popular policy instruments, imposition of taxes and requiring standards such as the ISO 14001 standard for environmental management systems, also tend to be the least effective in this list. These instruments have a symbolic worth however – policymakers, in the short term, appear to be making decisions and acting on them.

Meadows' system leverage points (in increasing effectiveness)

9. Numbers (subsidies, taxes, standards).
8. Material stocks and flows.
7. Regulating negative feedback loops.
6. Driving positive feedback loops.
5. Information flows.
4. The rules of the system (incentives, punishment, constraints).
3. The power of self-organization.
2. The goals of the system.
1. The mindset or paradigm out of which the goals, rules, feedback structure arise.

CONCLUSION

Ultimately, the vision for economic science must be to encourage a more critical perspective on itself and to work for improving the discipline's learning capabilities. Figure 2 presented a model of inquiry and learning that kept the underlying mental model outside of the learning process. Essentially, any changes to the mental model are incremental and likely not to be sufficient to keeping up with the dynamic reality that it attempts to understand and control. One solution is to recognize that the real world conditions have evolved to the point where economics require a paradigmatic shift. This demands that the existing mental models be re-evaluated and updated. The complex adaptive systems perspective and the associated methodologies require such a change. This is not to say that everything before must be abandoned, rather it reflects better the complexity of society.

Figure 5 modifies the basic single loop learning model by adding a direct link from "Observing consequences" to the mental model. This is intended to emphasize the need to evaluate observations with expectations based on theory and to use mismatches as important signals regarding the veracity of the existing models. This learning process has two loops. The inner loop relates to the development of formal models, and the outer loop focuses on improving the quality of the informal mental models.

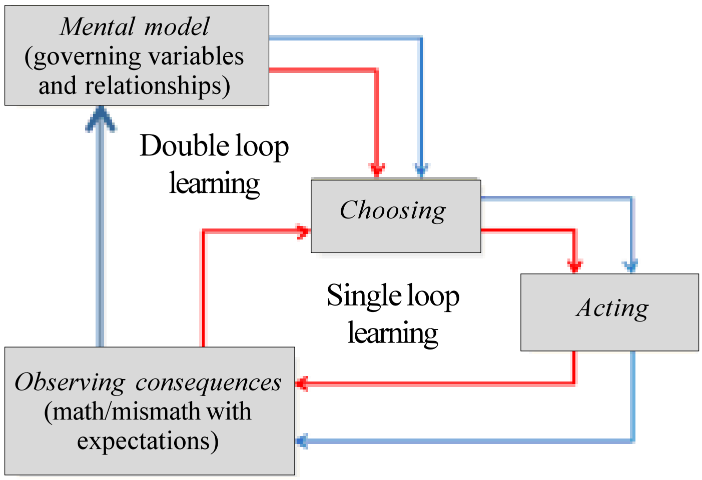

Figure 5. The double loop learning process
Source: adapted from Argyris and Schön [1978].

Movement in this direction is being made through the establishment of academic journals specializing in evolutionary economic behavior and complexity. Additionally, the establishment of high-profile research establishments such as the Santa Fe Institute serves to generate awareness of the opportunities and challenges offered by actively addressing complexity. The next big step is to bring these perspectives into a central position in the classroom.

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Carl Brønn

NAUKI EKONOMICZNE: NA AUTOSTRADZIE CZY DRODZE DONIKĄD?

Streszczenie

Budowa modelu jest podstawową metodą badań w zakresie nauk ekonomicznych od czasu wdrożenia technik matematycznych w XVIII w. Coraz bardziej zaawansowane modele, wykorzystujące coraz większe pakiety danych, odnoszące się do coraz nowszych obszarów, spowodowały rosnącą popularność badań przy zastosowaniu modeli, co skutkowało znaczącym postępem metodologicznym. Poza modelami ekonometrycznymi, łatwo poddającymi się weryfikacji, w ekonomii można zastosować także inne modele, tzw. modele myślowe, rzadko podlegające weryfikacji. Oba typy modeli nie są niezależne. Modele myślowe określają ramy, w których opracowywane są modele ekonometryczne. Zatem zrozumienie natury oddziaływania modeli myślowych jest ważne dla dalszego rozwoju nauk ekonomicznych. Pojawiły się już sygnały, że tradycyjne podejście do modelowania ekonomicznego jest niewystarczające dla zaspokojenia potrzeb obecnych wydarzeń w zrozumieniu ludzkich zachowań i analizy polityki. W artykule podjęto próbę analizy roli modeli myślowych w procesie rozwoju nauk ekonomicznych wskazując na nie jako na alternatywne metody badawcze, które wydają się być lepiej przystosowane do zaspokojenia potrzeb modelowania ekonomicznego.

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