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ECONOMIC MODELS AS CULTURAL ARTIFACTS
A PHILOSOPHICAL PRIMER***

Abstract
As economics became a model-based science, ontological nature, cognitive status, and practical uses of economic models came under the spotlight of philosophers of economics and economic methodologists. However, what was strikingly missing was the interest in the cultural dimension of economic modeling. Some calls for thematizing "cultural framework" (Mäki), "enculturation" (Goldschmidt, Remmele), or "culture patterns" (Benton) of economic models have appeared in recent years, and this paper aims at addressing such calls. To this end, we start with the artifactual approach to economic models (Morgan, Knuuttila, Halsmayer), which cuts across the idealization –construction debate, and complement this approach with the cultural-semiotic component, drawing from the symbolic anthropology of Clifford Geertz. We thus come up with an interpretation of economic models as cultural artifacts, which enables us to address the insufficiently explored question of style in economic modeling using Nelson Goodman's semiotic account of style.

Keywords: philosophy of economics, cultural semiotics, economic models, cultural artifacts, modeling styles

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> The rising interest of sociologists, anthropologists, psychologists, political scientists, and even now and then a rogue economist in the analysis of symbol systems poses — implicitly anyway, explicitly sometimes — the question of the relationship of such systems to what goes on in the world.
>
> Clifford Geertz, *Local Knowledge* (1983: 34-35)

Economics is a science that frequently builds and widely uses theoretical models. Contemporary economists no longer limit the description of their science to "analytical economics" (Samuelson 1975), "empirical science" (Leontief 1993), or "historical science" (Simon 1998), but also describe it in terms of "modeling science" (Rodrik 2015). The shift of economics towards a model-based science is by no means surprising; in this respect, economics follows a path taken earlier by natural, cognitive, and computer sciences (Gelfert 2016, Magnani, Casadio 2016, Magnani, Bertolotti 2017). Economic model thus replaced economic theory as the main unit of production, communication, and utilization of economic knowledge in the daily practice of economic research (Klein, Romero 2007, Goldfarb, Ratner 2008, Rodrik 2015, 2018). Such a conspicuous turn towards modeling in economics aroused philosophical and methodological interests in a model-based type of reasoning (Morgan 2012), in semantic relations between models and modeled systems (Mäki 1999, Reiss 2008, Claveau, Mireles-Flores 2014, 2016), in instrumental status of economic models (Boumans 2001, Reiss 2012), as well as in commonsensical basis of economic models (Hausman 1998, Mäki 2009, Hands 2012, Ross 2012, Guala 2012, Nagatsu, Poder 2019).

Undoubtedly, economics is populated by models of different nature and different cognitive status, but economic modeling is also immersed in a symbolic and material culture, and more precisely, in its specific historical-social forms. As Anna Alexandrova, Robert Northcott, and Jack Wright (2021: 55) have recently reminded philosophers of economics and economic methodologists, science is indeed "hospitable to distinctive epistemic cultures and that evaluating these cultures requires sensitivity to local circumstances and constraints," and economics is no exception. Such reasoning is in line with interpreting science as a domain of symbolic culture (Kmita 1996)[1] or a cultural system (Geertz 1973: 30, Elkana 1981: 6-10). Acknowledging that implies that

[1] Such a specification has profound consequences for our philosophical and methodological investigation, because, as Jerzy Kmita put it, "not only *one cannot study* scientific cognition *without* a theory of culture, but — what is more: . . . at least some central problems of theory of (scientific) cognition are dictated by certain assumptions of theory (philosophy) of culture, and they can be solved only with the use of these assumptions" (Kmita 1985: 6, our translation, emphasis added).

"we *cannot pretend* that meanings, values and symbols are mere window dressing" (Galison 1997: 670, emphasis added).

One of the first scholars explicitly referring to and consequently analyzing economics as a cultural system was Raymond Benton, according to whom "economics as a system of symbols and meanings provides the webs of significance within which most of us are suspended. It is a web that we ourselves have spun" (Benton 1986: 254-255). More recently, Nils Goldschmidt and Bernd Remmele, while sketching their anthropological theory of economics, stressed the relevance of culture "for the phenomena of economic science — that is, for the development of economic thought" (Goldschmidt, Remmele 2005: 455). They go as far as to laud "the acknowledgement of enculturation as a recurrently new, constructive historical process, . . . mandatory, also for economics" (Goldschmidt, Remmele 2005: 466). An equally strong argumentation concerning the specific type of scientific practice in economics — namely, economic modeling — has been recently applied by Uskali Mäki:

> Indeed, a broadening of the relevant issues — from the ontology of model targets and the semantics of model-world relations to the pragmatics and *cultural framework of economic modeling* — is needed for having a sophisticated conversation about the rights and wrongs of economics. (Mäki 2018: 4, emphasis added)

> In order to understand the performance of economics as a science (or as something else), its modeling practices (their styles, successes, and failures), and its intricate relations to policy-making, one must understand economics as social activity itself. This requires investigating economics as a discipline with an internal institutional and *cultural structure that shapes its functionings*. (Mäki 2021: 10, emphasis added)

This paper is an attempt at addressing the expectations embedded in the above-mentioned considerations. While Benton, Goldschmidt, Remmele, and Mäki have rightly identified the issue missing in the contemporary discussion on economics, we believe the question needs to be properly explicated. Therefore, we aim at filling in the missing elements in the contemporary philosophical and methodological reflection on economics — that is, the identification and thematization of both the presence of culture in economics and the cultural dimension of economic modeling.

Let us first unpack the question of the presence of culture in economics. There are at least two common ways of thematizing it. One tradition thematizes the presence of culture in economics in terms of value-ladenness (Weber 1904/1949, Gonzales 2013, Putnam, Walsh 2011, Boumans, Davis 2010, Mongin 2006). This approach, which we call a canonical one, is based implicitly on the following dilemma: value-ladenness is either inevitable or dangerous. If it is inevitable, it should be reconstructed via an adequate epistemological-methodological analysis (Longino 1990) and disclosed in economic

research (Reiss 2014). If it is dangerous, it should be eliminated by means of an epistemological-methodological analysis (Nagel 1961) and avoided in economic research (Robbins 1932). This canonical approach boils down to the problem of value-judgment, making culture present as axiology.

In the second tradition, the presence of culture in economics might be thematized in terms of enculturation (Goldschmidt, Remmele 2005, Chemla, Keller 2017, Nersessian 2006, 2017).[2] This approach, which we call a non-canonical one, seems to be based implicitly on the following dilemma: culture is considered either as "power" or as "ornament." If it is considered as "power," then a causal relation between culture and a given event, behavior, practice, institution, or economic process is investigated. If it is considered as "ornament," then only the aesthetic and rhetorical function of culture is ascribed to it. In this non-canonical approach, the presence of culture has not only an axiological but also a semiotic dimension. While we agree with this statement, we believe it is instructive to go beyond considering culture either as "power" or "ornament." This is why we follow Clifford Geertz in his understanding of culture as a context within which social events, behaviors, institutions, or processes can be intelligibly described (Geertz 1973: 14). Such a specification is important to our project in two ways: on the one hand, it implies that "'context' is always part of science — not as an external determinant of something that is pure scientific method or pure thought, but as part of the internal organization and performance of knowledge-developing and knowledge-grounding procedures" (Knorr Cetina 1991: 107); on the other hand, it points to two possible types of effects of cultural context on scientific practice — limiting or enabling.

To sum up our preliminary remarks, identification and thematization of economic models as cultural artifacts require, first, a non-standard approach to models to go beyond the prevailing approaches to modeling in philosophy of economics — namely, idealizational and constructivist approaches — and second, a non-canonical account of the relation between culture and science. We have already taken notice of a conspicuous shift in the way of thinking about the relation between culture and science: culture is increasingly treated neither as an ornament of science nor as its external determinant, but rather

[2] In a broader perspective, it might be interesting to consider whether enculturation relates only to the modeled target or whether it also relates to the economic model as such. If the former is the case, then we are dealing with the most common usage of the concept of culture by economists — i.e., culture as the set of values and beliefs influencing behavior of economic agents (cf. Brown 2008: 3, Roland 2015: 2, Bowles, Gintis 2008: 215-216, Guiso et al. 2006, Fernandez 2011, 2008). If the latter is the case, then we are dealing with not only the problem of culture-in-model but also the problem of model-in-culture. In this paper we focus only on the question of model-in-culture.

as a context within which the scientific products and research procedures are meaningfully interpreted (Geertz 1973: 14, Müller 2009: 637, Kralemann, Lattmann 2013: 3412).

The paper is organized as follows. After having sketched in the introductory remarks our philosophical and methodological stance, in section 1 we discuss the artifactual approach to models that, in our opinion, cuts across the idealization–construction debate. In section 2 we introduce some of Geertz's ideas, showing what philosophers of economics can learn from symbolic anthropology when it comes to scientific models, thus complementing the artifactual approach with the cultural-semiotic component. Then, in section 3 we turn to the question of modeling styles and discuss the benefits of applying the semiotic concept of style to economic modeling. Finally, in the concluding remarks we summarize our account and suggest further possible directions of research.

1. ARTIFACTUAL APPROACH TO MODELS

If we adopt the artifactual approach to models (models as epistemic artifacts), we do not limit ourselves only to a constructivist approach to models, as exemplified in how Robert Lucas' artificial systems were interpreted. While such artificial systems are obviously artifacts, it does not mean that they do not play a mediatory function, even if in comparison with realistically interpreted idealizational models this function is rather limited here. Still, idealizational economic models are also artifacts because, as Mary Morgan and Tarja Knuuttila noted, they are "partly . . . idealization[s] made up for expository reasons" (Morgan, Knuuttila 2012: 68). What is important, considering idealizational models as artifacts is not a proposal meant to deliver a new concept of idealization; it is rather "an alternative metalevel perspective to modeling" (Carrillo, Knuuttila 2021: 56). In this sense, the artifactual approach is non-standard and cuts across the idealizational–constructivist divide. Idealizations and constructivists' products are cultural, epistemic artifacts, but they are constructed and used in different ways and motivated by different cognitive goals. In this respect, double limitations imposed on building models are taken into account. These limitations are determined by cognitive goals and by available representational tools. In the non-standard, artifactual approach, the key is to take into account the "twofold character of models as unfolding objects constructed by employing already established *representational tools* in view of some *epistemic aims*" (Carrillo, Knuuttila 2021: 57, emphasis added). The standard approaches take into account cognitive goals

but neglect the issue of representational tools. However, if we take a closer look, it turns out that the issue deserves more attention, because not only do we have various representational tools but they also have different semiotic statuses. Thus emerges a problem of semiotic analysis and the question of the style of modeling. Let us take a look at two excerpts from Morgan's famous book:

> economic models may be constructed and played with like toys, but for the economist-scientist who works with such objects, models can be understood as *articulate artifacts — compressed accounts of things in the world* expressed in an appropriately specialized form and language. (Morgan 2012: 386, emphasis added)

> Economic models are pen-and-paper objects, *not objects of, or in, the world but artifacts made to represent — to depict, denote, or describe — things in the world* such as economic markets, consumption behavior, and so forth. The models of economists are diagrams, sets of equations, or accounts, in which economists adopt standardized and formalized conventions to denote their phenomena of interest. (Morgan 2012: 382, emphasis added)

First of all, one should note that the semiotic-artifactual approach to models allows to fully address one of the problems concerning modeling in economics that was pointed out by Morgan and Knuuttila — namely, the problem of "the roles of *content and materials in providing resources and constraints* to modelers" (Morgan, Knuuttila 2012: 81, emphasis added). This problem is multi-faceted, but its mere explicit formulation reveals it is at odds with purely fictional approaches, in which models are understood as imaginary objects. One of the main difficulties of this proposal is the issue of intersubjectivity and coordination of models: how mental states of modelers, which are not intersubjectively available, can be coordinated with the remaining components of the modeling practice? The problem of coordination is complex because it concerns the coordination of the model with the modeled-system, of the model with its description, and, last but not least, coordination of the model within the scientific community. The solution to the coordination problem consists in assuring that models have an intersubjective character. A warranter of models' intersubjectivity is culture and, more precisely, the usage of culturally-shared representational means in the modeling practice:

> It is these representational means and the cultural norms and rules governing their use and interpretation — in particular contexts — that draw together the various aspects of modeling: the imaginings of scientists, the abstract and other structures created by different kinds of models, and, finally, various kinds of scientific targets. (Knuuttila 2021a: S5087)

An important advantage of the semiotic-artifactual approach is that it takes the issue of models' intersubjectivity seriously. This intersubjectivity is already seen at the stage of model-building, because they are created from

"culturally shared external representational means" (Knuuttila 2021a: S5086). Axel Gelfert (2015: 60) also stressed that systems of symbols in the form of mathematical formalism, diagrams, or sets of iconic signs represent *collective representational resources*. An abstract characteristic of these systems accounts for only a part of their characteristics, because what is important is that these systems are a crucial component of everyday research practice. Symbolic resources are embedded in social research practice that maintains their vitality. Therefore, cultural symbolic systems are resources used in creating economic models and providers of their meaning. Economists take advantage of the cultural fund of considerable symbols. This however means that the semantics of economic models becomes an important issue. If economic models are artifacts, one cannot neglect the culturally-symbolic level and reduce the modeling activities to the cognitive level, where "the ways in which cognitive agents can perform inferential tasks with different kinds of external aids are empirical and therefore proper objects of study for cognitive science, not philosophy. There are genuine philosophical puzzles, but the problem of representation is not one of them" (Kuorikoski, Ylikoski 2014: 12). Putting aside the fact that it is a clear attempt to escape semantic difficulties concerning representation and to delegate them to rather unspecified empirical research, it is also a failure to notice the philosophical consequences of distributed cognition and the status of external representations. This is strongly accentuated by Lorenzo Magnani, for whom the cognitive level in modeling is very important but who does not neglect the cultural level:

> The cognitive process is distributed between a person (or a group of people) and external representation(s), and so obviously embedded and situated in a society and in a historical culture. (Magnani 2009: 52-53)

The above excerpt adequately illustrates issues concerning modeling in the artifactual approach, as well as its historically-cultural, socially-institutional, and individually-cognitive references. It is also a way to overcome the doubly naïve thinking about models: their content is not directly taken out from the world or from the modeler's mind. Models are created and function in a given cultural context and are publicly available to particular communities; they are "concretely embedded intersubjectively available objects" (Knuuttila 2021b: 8).

Another issue pointed out by Morgan and Knuuttila is the issue of material as a resource in model-building. Given the fact that in the abstract approach to models this problem is treated as inessential, it requires special attention and is currently being thoroughly investigated. The inessentiality of the problem of models' materiality in the standard approach can be illustrated by the following excerpts:

> Since virtually any medium can be used to provide a structural representation of anything else, it should be *medium-indifferent*, insensitive to the idiosyncrasies of particular media. (Swoyer 1991: 453-454, emphasis added)

> The point, of course, is that the *specific material of the model is irrelevant*; rather it is the structural representation, in two or three dimensions, which is all important. (French, Ladyman 1999: 109, emphasis added)

> This outcome is essential for isolative modeling, while *the precise way in which isolations are implemented is inessential* (Mäki 2009: 31, emphasis added).

In the abstract approach to models, questions of materiality are not important because the material aspect is residual: it is the whole rest that is accidental and does not concern the abstract-structural nature of the model. Let us consider for instance Thomas Schelling's checkerboard, which can be made of wood, plastic, metal, paper, can be virtual or even imagined. In the case of a consistent and analytical semiotic-artifactual approach, the question becomes much more subtle and refined. We get a "neither-nor" option: "a model reduces neither to an abstract entity nor to the representational means with which it is constructed" (Boon, Knuuttila 2009: 724). This statement is very important: in the artifactual approach there is no clear distinction between concrete and abstract models; each model has these dimensions albeit present in various combinations and proportions.

To sum up, in our consideration we adopt a stance according to which "the artifactual approach to modeling stands on two pillars: (i) the constrained construction of a model that is due to its intended use(s), and (ii) the representational tools used in producing a model" (Knuuttila 2021b: 65). In our investigation, we are especially interested in the second pillar. We argue that in order to address these questions, one should look particularly closely at symbolic anthropology and cultural semiotics with Geertz as one of the most renowned representatives in these fields.

2. MODELING AND SYMBOLIC ANTHROPOLOGY

The semiotic-artifactual approach to economic models refers to the concepts of culture and of symbolic systems. It is worth complementing this approach with works from the field of cultural sciences. Symbolic anthropology of Geertz provides some valuable insights in this respect; what is more, the problem of building and using models and their artifactual character is being explicitly dealt with in this framework. According to Geertz, culture is a "historically transmitted pattern of meanings embodied in symbols" (Geertz

1973: 89). The term "symbol" is used by the author in a broad sense — that is, any object, act, quality, or relation which serves as a vehicle for meaning. On the other hand, for Geertz, models are "sets of symbols whose relations to one another 'model' relations among entities, processes or what-have-you in physical, organic, social, or psychological systems by 'paralleling,' 'imitating,' or 'simulating' them" (Geertz 1973: 93). States and processes of models are adjusted to states and processes of modeled systems — that is, "matching of the states and processes of symbolic models against the states and processes of the wider world" (Geertz 1973: 78). Construction and usage of symbolic models is a specific feature of human thinking; thinking is in fact modeling. On the other hand, while creating models, one uses "cultural sources — the accumulated fund of significant symbols" (Geertz 1973: 49). In this sense, modeling is a cultural act, or in other words, a symbolic action. These actions are certain social events that consist in creating, understanding, and using cultural artifacts. Geertz put a great emphasis on the intersubjective tangibility of models — on their external, artifactual, and at the same time symbolic features. Cultural artifacts are thus "tangible formulations of notions . . . , concrete embodiments of ideas, attitudes, judgments . . . or beliefs" (Geertz 1973: 91). What is equally important, investigating models is investigating culture and thus investigating human thinking:

> thought consists of the construction and manipulation of symbol systems, which are employed as models of other systems, physical, organic, social, psychological, and so forth, in such a way that the structure of these other systems — and, in the favorable case, how they may therefore be expected to behave — is, as we say, "understood" (Geertz 1973: 214).

Models are extrinsic sources of information. They are external — that is, exosomatic — and publicly available. In this sense, Geertz's models have the status of cultural artifacts with semiotic characteristics. They are external representations, and modeling consists in constructing and manipulating them. Models are constructed in order to enable searching for and obtaining information and, more precisely, in order to expand and increase the possibility of obtaining information. Each symbolic model belongs to a cultural system: ideology, religion, common sense, art, science, law, or morality. Cultural systems are integrated sets of models. Different cultural systems are different *modes of symbolic formulations*, and moving between them is not continuous but discontinuous. It is also possible to construct models in different systems — for instance, ideological, religious, or scientific — but concerning the same situations. However, if these models belong to different modes of symbolic presentation, they yield different information, even in cases

where the situation is the same. Most often we then have a clash of models because they belong to cultural systems between which there are leaps.

Geertz differentiates between *models of* and *models for*, and therefore between two corresponding types of modeling:

> — modeling "of" — "the manipulation of symbol structures so as to bring them, more or less closely, into parallel with the pre-established nonsymbolic system" (Geertz 1973: 93);
> — modeling "for" — "the manipulation of the nonsymbolic systems in terms of the relationships expressed in the symbolic" (Geertz 1973: 93).

These are the two aspects of symbolic modeling, in which either manipulation of the model or manipulation of the modeled-system is considered. As mentioned above, symbolic models can thus be both *models of* and *models for*, which is made possible due to the occurrence of cultural symbolizing: "the intertransposability of models *for* and models *of* which symbolic formulation makes possible is the distinctive characteristic of our mentality" (Geertz 1973: 94). Within the framework of Geertz's symbolic anthropology, the problems of modeling and thinking remain tightly interconnected. However, one cannot reduce models to mental models. According to Geertz, models are intersubjective artifacts. Human thinking has primarily an intersubjective dimension and only secondarily a private one. The secondary role does not obviously mean that the private dimension fails to play an important role. It is therefore unjustified to claim that symbolic anthropology ignores the cognitive dimension and mental models. Thinking — that is, in fact, modeling — has "*both* the cognitive constraints of the evolving brain *and* the communicative contexts of human cultures" (Geertz 2013: 192, emphasis in original). While addressing the question of modeling, one has to comply with proper levels of analysis.

From the vantage point of symbolic anthropology, we have three levels of analysis of cultural systems and, at the same time, of models belonging to them: (i) history of forming concepts and meanings, (ii) social functioning of symbols, and (iii) their individual application: "the symbol systems . . . are historically constructed, socially maintained, and individually applied" (Geertz 1973: 363-364). Since economic models are drawn from a rich fund of interpersonally accessible symbols, their intersubjective character is no mystery. The intersubjective communicability of economic models is guaranteed by placing the meaning in external, publicly available models considered as cultural artifacts. It is also crucial that economic models as specific cultural patterns — *symbolic contrivances* — enter into the public sphere of discussion and critique, which makes the bundles of meanings they convey intersubjectively criticizable, verifiable in a broad sense: "It was these contriv-

ances, carriers of meaning and bestowers of significance . . . that render them public, discussable, and, most consequentially, susceptible of being critiqued and fought over, on occasion revised" (Geertz 2000: 15).

Geertz's approach to culture is visibly focused on investigating intersubjective and tangible cultural patterns in the form of artifact-like models. Geertz was "an obsessive scribe of observable human artifacts. Culture is to be inferred from the patterning of these artifacts" (Shore 1988: 22). This focus undoubtedly contributed to his success in anthropological field research (in Indonesia and Morocco). It should be stressed though that such a research focus has solid and thoroughly thought-out semiotic grounds. However, it is not the semiotics of disembedded signs and abstract semiotic systems. What is typical of Geertz's cultural symbols is their embeddedness and connectedness (Gulick 1988: 143). Cultural meanings are neither ideal objects from the Platonic realm nor unobservable mental content. They are always embedded in intersubjective communication, in concrete language games played in specific discourse communities. It is therefore pointless to ask about cultural meaning in a given system with no connection to its public vehicles. Cultural symbols are always public, and their content is also (at least in principle) intersubjectively available, because they are "envehicled meanings" (Geertz 1980: 135). Of course, in practice we do not deal with isolated symbolic units: symbols are always connected with other symbols and create greater integrated entities — models and cultural systems. This integration is logico-meaningful as we take into account the issues of style, logical consequence, meaning, and value. The outcomes of such an integration are bigger entities understood "as systems of interacting symbols, as patterns of interworking meanings" (Geertz 1973: 207). The concept of logico-meaningful integration of models and cultural systems that refers to the notion of style derives from the writings of Pitirim Sorokin, in which strong focus is put on the fact that the outcomes of integration are "consistent *styles*, typical *forms*, and significant *patterns*" (Sorokin 1957: 10, emphasis in original). As this paper focuses mainly on economic models viewed as cultural artifacts, in the following section we limit the discussion to the issue of modeling styles (Knuuttila 2009: 60, Halsmayer 2014: 382, Frigg, Nguyen 2017: 95). This issue, although taken notice of in contemporary literature, has not been explicitly thematized.

3. THE QUESTION OF MODELING STYLES

The thematization of the question of modeling style requires looking into both model-building and model-using-related issues. Let us start with the following quote, which explicitly shows the specificity of economic models:

> economic models are not made in the *materials of the economy: hydraulic machines, diagrams, equations* are not economic actors and these *artifacts of economic science* are rarely directly performative as models. (Morgan, Knuuttila 2012: 75, emphasis added)

This statement is of particular significance for developing a semiotic analysis of economic models for at least two reasons. The first concerns economic model-building with special attention attributed to models' inputs, and the second issue concerns economic model-using. Both issues are interdependent. Let us start with the former. Marcel Boumans (1999) draws attention to the ingredients economic models are made of and to the ways in which these ingredients are integrated — that is, to what is built in a model and how it is built in. The author proposed a list of basic ingredients economic models are made of, including theoretical notions, mathematical concepts, mathematical techniques, stylized facts, empirical data, policy views, analogies, and metaphors (Boumans 1999: 93).[3] A good illustration of economic models as not being constructed "in the materials of the economy" is the case of the Dutch central bank thoroughly analyzed by Boumans. The central bank decided to make the initial econometric model called MORKMON, composed of 164 mathematical equations, more intelligible. To do so, the model first underwent "stylization," with the number of variables considerably reduced, and was subsequently turned into FYSIOEN, which is "not a physical model but a computer animation of a hydraulic system representing MORKMON" (Boumans 2012b: 146). The analysis of these models allows us to state that they have a dual nature as far as epistemic dimension is concerned: "models are *both instrument and . . . representation*, camera and snapshot together" (Boumans 2005: 273, emphasis added). This dual nature of economic models implies that one cannot speak of fully transparent representations — the representational side has to guarantee model's intelligibility, while the instrumental side has to secure model's tangibility. What is important is that model-building is also "*guided by* the symbolic, mathematical, conceptual and other *available resources*" (Carrillo, Knuuttila 2022: 52, emphasis added) apart from utilizing them only as inputs or ingredients.

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[3] It is worth noting that particular ingredients differ in terms of ontological status, and ingredients deriving from mathematics are attributed a quasi-material status (Boumans 2012a: 307).

Let us now turn to the question of economic model-using, which turns on the resources used in model-building although a human factor also plays a role. As was mentioned above, the ingredients a model is made of and ways of combining them "determine the kinds of manipulations that are allowable but it is economists' subject knowledge that determines which manipulations are relevant and of interest" (Morgan 2014: 232). Therefore, one cannot say that economic models "animate" themselves as if they were active agents; the models are activated by their users, who do it with a certain purpose and in a specific domain. Also, representational devices of which models are made cannot be omitted, because they are the ones determining admissible manipulations.

From the point of view of the semiotic-artifactual approach, playing with models takes a tangible form because manipulation with the use of model does not boil down to purely formal-mathematical operations but also encompasses material actions concerning material ingredients of models and — what is particularly important — semiotic operations referring to representational devices used in the construction of models and the embodied meanings inferred from semiotic resources of a given cultural system. And while model inputs are practically unlimited, the choice of representational devices does impose some constraints on model outputs understood as their possible uses and manipulations conducted on their basis. Of course, the intended use of models by modelers is also taken into account. Model as an artifact is marked by this intended use, which does not however mean that this intention fully determines its further use: "although models bear traces of their intended use in their construction, they can be also used in many other ways" (Knuuttila, Voutilainen 2003: 1494). Model as an artifact bears traces of the use intended by the modeler. However, regardless of the intention of the modeler, properties that are not intended are being built in a model. This issue raises a problematic property of models:

> The artifactual approach . . . recognizes that models are not just transparent representations of some selected aspects of reality, the construction of a model is partly dictated by the representational modes and media used. This artificiality of models and the affordances for multiple uses and interpretations embedded in their actual construction explains many of their unintended features, too. The actual model is often much richer than its intended character, but this does not boil down to scientists pretending it to be richer. (Knuuttila 2021a: S5091)

What we have here is a thesis on representational non-transparency of models (Knuuttila 2011: 267), important for the semiotic-artifactual approach. There are many reasons why models are often considered to be transparent in the representational sense. Below we focus only on three of them.

Firstly, models are often acknowledged to be abstract entities and even if they are not purely abstract, it is their underlying structure that counts. Models are then considered as independent of representational devices.

Secondly, it is often believed that models are formulated as simplifications or idealizations of their target systems, in the sense that models are not excessive, that they do not add anything to representation; and even if they do, these features are easy to discern. However, as was mentioned above, models often do have an excessive character, which results from the devices of representation used. Thus, contrary to simplifications, these excessive elements are not the intended aims of modelers.

Thirdly, as Boumans (2005: 275-276) points out, the choice of mathematical formalism in model-building is not always as transparent as some economists believe it to be.

To sum up, representational non-transparency of models is the consequence of their artifactual characteristics. These artifactual characteristics were, incidentally, noticed by Marx Wartofsky (1979: 26) a long time ago: "models, like characters in fiction, are not transparent as appearances are; they are deliberate constructions, artifacts." If we agree that models are frequently non-transparent, it is advisable to focus on a specific symbolic system "to determine what it is and what it refers to" (Goodman 1984: 137). In other words, it means concentrating on different types of representation that convey different semiotic functions, and not only on objects that the symbolic system refers to. Addressing the non-transparency thesis without a semiotic analysis is a tall order.

The view that only the abstract structure of a model determines its representational power is thus rejected. Approaches based on morphisms (isomorphism, homomorphism, or partial homomorphism) are also abandoned. What, then, should we direct our efforts at? "So it seems that styles of representation other than structure-preserving mappings have to be recognized" (Frigg, Nguyen 2016). Therefore, the realization that economic models are non-transparent brings our attention to modeling styles. Opacity reveals the style. The problem of style in the context of modeling was clearly formulated by Roman Frigg (2006: 50): "As in painting, there seems to be a variety of representational styles in science. But what are these styles (or 'modes of representation')?" Still, the problem of style is not uniform, which is manifested in various uses of the term "style" by Frigg and Nguyen. On the one hand, we have morphism-styles: isomorphic style, homomorphic style, etc. On the other, analog and idealized representations considered as different styles are also discussed (Frigg, Nguyen 2020: 10). Finally, there is "style of causal modelling" and "style of structural modelling" (Frigg, Nguyen 2020: 43).

Such heterogeneity certainly makes it impossible to work out the taxonomy of modeling styles; we rather have a collection of different applications of the word "style." Frigg and Nguyen admit that it is impossible to make a complete list of styles; such a list remains open-ended, and new styles will be gradually added to it. It is also impossible to distinguish one basis for differentiating between styles of modeling. Frigg and Nguyen's approach:

> allows for style to be a multi-faceted aspect of scientific practice: some modelling styles depend on the kind of objects used as the carrier (one might identify the model-organism-style); other styles might depend on the sorts of interpretations used (economy-representations might thus form a style); and yet others might depend on the kinds of key used. (Frigg, Nguyen 2020: 180)

Still, the issue of style is by no means superfluous while discussing the problem of economic modeling, because what is crucial is that "the same target can be represented in different styles" (Frigg, Nguyen 2020: 1). Explicitly addressing the question of style is related to problems, appearing in contemporary literature on philosophy and methodology of economics, concerning the use of mutually inconsistent models of the same target systems in order to obtain information about the target (Lisciandra, Kormbacher 2021: 203). However, as it has been signaled, stylistic differentiation is not made based on one distinguished feature: style is multi-faceted. And while presenting a comprehensive taxonomy of styles is rather impossible, one can try to specify the problem of style more clearly.

Firstly, the concept of style cannot be understood in a classical or even commonsensical manner — that is, as a certain formal property concerning the model's "how" juxtaposed with its content (model's "what") (Goodman 1978: 23-27, Meskin 2005: 495-496, Heinemann 2010: 160-161). Secondly, based on what Frigg and Nguyen said, we can conclude that style can concern the questions of a model's ontology, as well as epistemological or semantic problems. However, it is not the case that all of these issues shape the modeling style. Only issues that impact the semiotic functions of a model are taken into account — that is, those that shape the model's representational and instrumental functions as far as its symbolic (sign-related) character is concerned. Considering the problem of models' ontology, the style is about mixing components of the model, representational means and materials. A semiotic-artifactual approach to models is not about a uniform approach to ontology of models as attention is paid to diversity of models' components. Gelfert calls it mixed ontologies:

> the ontological picture that emerges from the artifactual approach to models is decidedly mixed: models will typically consist of a combination of different materials, media and formats, and deploy different representational means (such as pictorial, symbolic,

> and diagrammatic notations) as well as empirical data and theoretical assumptions. (Gelfert 2017: 21)

In this stylistic aspect, the variety of representational means used to construct a model is taken into account. Thus, economic modeling always requires "a combination of graphic, verbal and algebraic analyzes" (Blaug, Lloyd 2010: 9-10). However, models' inputs can be of factual or fictional nature, which are rather intertwined than separated. The epistemological status of models and its impact on modeling style has to be accounted for here:

> it is not whether the *exact status of the model* is fictional or factual that matters, . . . it appears crucial for economists that model have this *flexible status*, sometimes as fictions, sometimes as factual, and sometimes as mixtures. (Morgan 2014: 264-265, emphasis added)

Economic models thus have *mixed ontological status* and *flexible epistemological status*. It bears repeating that Frigg and Nguyen's motivation behind addressing the problem of style was that "there can [be] a *great variety of representational strategies* even within a certain type of representation" (Frigg, Nguyen 2020: 20, emphasis added). As it seems impossible to come up with a taxonomy of modeling styles, we should limit ourselves to their framework characteristics. We certainly cannot speak of style as an exclusively formal property of models. Therefore, it seems that the semiotic concept of style by Nelson Goodman (1978) can be applied to the issue of modeling styles. Goodman was opposed to the traditional approach, based on what he considered a misleading juxtaposition between form and content. In particular, he did not identify style with structure and rejected a close link between style and the author's intention. Although Goodman applied the problem of style to works of art, he underlined on numerous occasions that it also refers to scientific products[4] and generally speaking "style indeed pertains only to artifacts" (Goodman 1978: 36). Two issues are important here for the semiotic definition of style. Firstly, style is a certain complex property of artifacts, which concerns the semiotic functions performed by this artifact. "Style has to do exclusively with the symbolic functioning of a work as such" (Goodman 1978: 35). These properties do not have to depend on authors' intentions, or even on their awareness. Secondly, style as a complex property can be decomposed into various stylistic properties. A given property is stylistic:

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[4] "You are beginning to grasp a new concept that cuts across the old ones. This, I think, underlines what I was saying about the relationship between art and science, for that's what you do in science, too. You begin to see new connections and make new discriminations, and style is a very good example of this." (Goodman 1984: 195)

> when it associates a work *with the other works* of one rather than another artist, period, region, school, etc. A stylistic feature, in my view, is a feature that is exemplified by the work and that contributes to the placing of the work in one among certain significant bodies of work. (Goodman 1984: 131, emphasis in original)

Therefore, stylistic properties associate artifacts typical of particular authors, schools, regions, or periods. According to Goodman, style is a metaphorical signature. In the context of economic models, we mean here such theoretical conceptions whose specificity is tightly linked to their author, scientific tradition, or research toolkit. Such specificity can be undoubtedly noted in the case of such well-known economic models as Edgeworth box, Marshallian cross, Frank Knight's wheel of wealth, Robert Lucas' parallel or analog system, Thomas Schelling's chessboard model, Hotelling's location model, Hayeckian triangle, Oskar Lange's cybernetic structures, Michał Kalecki's business-cycle model, Laffer curve, or Leszek Nowak's idealizational approach.[5]

What follows from this approach is that a given artifact can be produced in different styles depending on what other artifacts it is referred to — for instance, to other works of the same author (individual style) or to artifacts typical of a given historical period (epochal style). The concept of style is therefore a dynamic and relational one (Gelfert 2012: 133), which is undoubtedly a property desired in the case of modeling style. Such a supraindividual association of models' stylistic properties is particularly important here, because it draws attention to resources available at a given stage of modeling-practice development: "Stylistic practice involves a process of *bricolage*, by which people combine a range of existing resources to construct new meanings or new twists on old meanings" (Eckert 2004: 43). The main source of stylistic differentiation of economic models lies exactly in the available semiotic resources and variety of their possible combinations. Let us stress once more that what we mean here are not only internal properties of these resources but also their relational properties concerning their referential possibilities. It is also to be noted that we take into account both direct and indirect, literal and figurative references — in other words, all available semiotic resources:

> Since both science and art consist very largely in the processing of symbols, an analysis and classification of types of symbol systems — linguistic, notational, diagrammatic, pictorial, etc. — and of literal and figurative symbolic functions — denotation, exemplification, expression, and reference through chains of these — provides an indispensable theoretical background. (Goodman 1984: 149)

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[5] The problem of style as a metaphorical signature will be dealt with in detail in a separate semiotic-methodological study.

CONCLUDING REMARKS

This paper attempts at sketching a philosophical primer for viewing economic models as cultural artifacts. This required an approach different from the standard one — namely, a semiotic-artifactual approach. If economic models are artifacts, then the cultural-symbolic level cannot be ignored, and modeling activities should not be reduced to the cognitive level:

> If we ascribe to individual minds in isolation the properties of systems that are actually composed of individuals manipulating systems of cultural artifacts, then we have attributed to individual minds a process that they do not necessarily have, and we have failed to ask about the processes they actually must have in order to manipulate the artifacts. (Hutchins 1995: 173)

Our reasoning was guided by Geertz's recommendation to "make 'culture' into a delimited notion, one with a determinate application, a definite sense and a specified use" in order to make this concept analytically useful at all (Geertz 2000: 13). Under certain conditions, this recommendation also pertains to the very concept of style, which we found insightful for investigating the specificity of economic modeling. We thus share Verena Halsmayer's view that "what economists believe to be 'typical' situations and what images they have of 'the economy,' 'the economic world,' and 'the real world' are historically contingent, just as the specific styles of depicting them" (Halsmayer 2014: 382). Therefore, it seems reasonable and insightful to speak of modeling styles in economics. As there are numerous approaches to style, we are interested in the semiotic account of style as specified, from various angles, by scholars such as Ernst Cassirer, Nelson Goodman, Ernst Gombrich, and Herbert Simon. Cassirer stresses the descriptive feature of the concept of style: "what style-concepts present *is not an ought* but simply an 'is'" (Cassirer 1961: 126-127, emphasis added). Goodman, on the other hand, points out that style is not only the question of form but also the question of content. Such a combination of stylistic features constitutes a figurative signature of the modeler(s). Also, if one compares modeling to creating works of art or craft, Gombrich's remark that "artists need a style adapted to a task" becomes useful (Gombrich 1961: 68). Finally, looking at the conspicuous heterogeneity of economic models, it would be worth investigating in the future the process of designing models as, according to Simon, it is one of the most important sources of differences in style (Simon 1971: 8, 10).

To sum up, it has often been acknowledged that the "original aim" or the "first role" of economic methodology is to increase methodological awareness among economists (Vromen 2021: 28, Dow 2012: 105, 128). The culturally

informed philosophy of economics or economic methodology through a cultural lens may contribute to increasing the semiological awareness among economists, which is especially important as "*ignoring* culture may be possible, but *avoiding* culture is impossible" (Storr 2015: 35, emphasis added). It may also shed new light on the controversy around the cognitive status of economic models, which is not a purely philosophical question discussed within the academia, but it also resonates outside the academia and bears a broader cultural significance: "there remains the question of what exactly are philosophical and *cultural implications* of adopting a realist or antirealist position on models and science" (Murad 2011: 260, emphasis added). Certainly, economics is a model-based science, but it is also a cultural system. From the perspective of the semiotic account of culture, "if one takes . . . collectively sustained symbolic structure, as a means of 'saying something of something' . . . then one is faced with a problem *not in social mechanics but social semantics*" (Geertz 1973: 448, emphasis added).

In this paper, we have focused on the philosophical and methodological issues related to the cultural-artifactual approach to economic models and modeling. Certainly, in order to cover the cultural dimension of economic modeling more fully a separate and detailed semiotic investigation is needed. Such a need has been noticed by Halsmayer (2018, 2019), who, while proposing an artifactual view of economic models on the grounds of economics historiography, clearly emphasized that relational properties are the key features of economic models, which "involves the semantic and symbolic dimensions of artifacts" (Halsmayer 2018: 629). In recent years, some studies on the semiotics of scientific models have also appeared (Nöth 2018, Kralemann, Lattmann 2012, 2013). What we would like to pursue in further research, however, is to take the tradition of cultural and social semiotics and to draw semiotics of economic models and modeling from there.

BIBLIOGRAPHY

Alexandrova A., Northcott R., Wright J. (2021), "Back to the Big Picture," *Journal of Economic Methodology* 28(1), 54-59. https://doi.org/10.1080/1350178X.2020.1868772

Boon M., Knuuttila T. (2009), "Models as Epistemic Tools in Engineering Sciences" [in:] *Philosophy of Technology and Engineering Sciences*, A. Meijers (ed.), Amsterdam: Elsevier, 693-726. https://doi.org/10.1016/B978-0-444-51667-1.50030-6

Boumans M. (1999), "Built-In Justification" [in:] *Models as Mediators: Perspectives on Natural and Social Sciences*, M. S. Morgan, M. Morrison (eds.), Cambridge: Cambridge University Press, 66-96. https://doi.org/10.1017/CBO9780511660108.005

Boumans M. (2001), "Fisher's Instrumental Approach to Index Numbers," *History of Political Economy* 33(5), 313-344. https://doi.org/10.1215/00182702-33-Suppl_1-313

Boumans M. (2005), "Models in Economics" [in:] *Elgar Companion to Economics and Philosophy*, J. B. Davis, A. Marciano, J. Runde (eds.), Cheltenham, Northampton: Edward Elgar, 260-282.

Boumans M. (2012a), "Mathematics as Quasi-Matter to Build Models as Instruments" [in:] *Probabilities, Laws, and Structures: The Philosophy of Science in a European Perspective 3*, D. Dieks et al. (eds.), Springer, 307-318. https://doi.org/10.1007/978-94-007-3030-4_22

Boumans M. (2012b), "Visualisations for Understanding Complex Economic Systems" [in:] *Ways of Thinking, Ways of Seeing, ACES 1*, Berlin, Heidelberg: Springer, 145-165. https://doi.org/10.1007/978-3-642-25209-9_7

Boumans M., Davis J. (2010), *Economic Methodology: Understanding Economics as a Science*, New York: Palgrave Macmillan.

Bowles S., Gintis H. (2008), "Culture Matters: Inferences from Comparative Behavioral Experiments and Evolutionary Models" [in:] *Explaining Culture Scientifically*, M. J. Brown (ed.), Seattle–London: University of Washington Press, 211-227.

Brown M. J. (2008), "Introduction: Developing a Scientific Paradigm for Understanding Culture" [in:] *Explaining Culture Scientifically*, M. J. Brown (ed.), Seattle–London: University of Washington Press, 3-16.

Carrillo N., Knuuttila T. (2021), "An Artifactual Perspective on Idealization: Constant Capacitance and the Hodgkin and Huxley Model" [in:] *Models and Idealizations in Science: Artefactual and Fictional Approaches*, A. Cassini, J. Redmond (eds.), Cham: Springer, 51-70. https://doi.org/10.1007/978-3-030-65802-1_2

Carrillo N., Knuuttila T. (2022), "Holistic Idealization: An Artifactual Standpoint," *Studies in the History and Philosophy of Science* 91, 49-59. https://doi.org/10.1016/j.shpsa.2021.10.009.

Chemla K., Keller E. F. (ed.) (2017), *Cultures without Culturalism: The Making of Scientific Knowledge*, Durham–London: Duke University Press. https://doi.org/10.1515/9780822373094

Claveau F., Mireles-Flores L. (2014), "On the Meaning of Causal Generalisations in Policy-Oriented Economic Research," *International Studies in the Philosophy of Science* 28(4), 397-416. https://doi.org/10.1080/02698595.2014.979669

Claveau F., Mireles-Flores L. (2016), "Causal Generalisations in Policy-Oriented Economic Research: An Inferentialist Analysis," *International Studies in the Philosophy of Science* 30(4), 383-398. https://doi.org/10.1080/02698595.2017.1331976

Dow S. C. (2012), *Foundations for New Economic Thinking: A Collection of Essays*, London: Palgrave Macmillan. https://doi.org/10.1057/9781137000729

Elkana Y. (1981), "A Programmatic Attempt at an Anthropology of Knowledge" [in:] *Sciences and Cultures: Anthropological and Historical Studies of the Sciences*, E. Mendelsohn, Y. Elkana (eds.), Dordrecht: Reidel, 1-76. https://doi.org/10.1007/978-94-009-8429-5_1

Eckert P. (2004), "The Meaning of Style," *Texas Linguistic Forum* 47, 41-53.

Fernández R. (2008), "Culture and Economics" [in:] *The New Palgrave Dictionary of Economics*, 2nd edition, S. Durlauf, L. Blume (eds.), Basingstoke–New York: Palgrave Macmillan. https://doi.org/10.1057/978-1-349-95121-5_2192-1

Fernández R. (2011), "Does Culture Matter?" [in:] *Handbook of Social Economics, Vol. 1A*, J. Benhabib, A. Bisin, M. O. Jackson (eds.), Elsevier, 481-510. https://doi.org/10.1016/B978-0-444-53187-2.00011-5

French S., Ladyman J. (1999), "Reinflating the Semantic Approach," *International Studies in the Philosophy of Science* 13, 103-121. https://doi.org/10.1080/02698599908573612

Frigg R. (2006), "Scientific Representations and the Semantic View of Theories," *Theoria* 55, 49-65.

Frigg R., Nguyen J. (2016), "Scientific Representation" [in:] *The Stanford Encyclopedia of Philosophy* (Winter 2021 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/win2021/entries/scientific-representation

Frigg R., Nguyen J. (2017), "Models and Representation" [in:] *Springer Handbook of Model Based Science*, L. Magnani, T. Bertolotti (eds.), Cham: Springer, 49-102. https://doi.org/10.1007/978-3-319-30526-4_3

Frigg R., Nguyen J. (2020), *Modelling Nature: An Opinionated Introduction to Scientific Representation*, Cham: Springer. https://doi.org/10.1007/978-3-030-45153-0

Galison P. (1997), "Material Culture, Theoretical Culture, and Delocalization" [in:] *Science in the Twentieth Century*, J. Krige, D. Pestre (eds.), Amsterdam: Harwood, 669-682.

Geertz A. W. (2013), "The Meaningful Brain: Clifford Geertz and the Cognitive Science of Culture" [in:] *Mental Culture: Classical Social Theory and the Cognitive Science of Religion*, D. Xygalatas, W. W. McCorkle (eds.), London: Routledge, 176-196.

Geertz C. (1973), *Interpretation of Cultures*, New York: Basic Books.

Geertz C. (1980), *Negara: The Theatre State in 19th Century Bali*, Princeton: Princeton University Press.

Geertz C. (1983), *Local Knowledge*, New York: Basic Books.

Geertz C. (2000), *Available Light: Anthropological Reflections on Philosophical Topics*, Princeton: Princeton University Press.

Gelfert A. (2012), "Art History, the Problem of Style, and Arnold Hauser's Contribution to the History and Sociology of Knowledge," *Studies in East European Thought* 64, 121-142. https://doi.org/10.1007/s11212-012-9163-5

Gelfert A. (2015), "Symbol Systems as Collective Representational Resources: Mary Hesse, Nelson Goodman, and the Problem of Scientific Representation," *Social Epistemology Review and Reply Collective* 4, 52-61.

Gelfert A. (2016), *How to Do Science with Models: A Philosophical Primer*, New York: Springer.

Gelfert A. (2017), "The Ontology of Models" [in:] *Springer Handbook of Model Based Science*, L. Magnani, T. Bertolotti (eds.), Cham: Springer, 5-24. https://doi.org/10.1007/978-3-319-30526-4_1

Goldfarb R., Ratner J. (2008), "'Theory' and 'Models': Terminology through the Looking Glass," *Econ Journal Watch* 5(1), 91-108.

Goldschmidt N., Remmele B. (2005), "Anthropology as the Basic Science of Economic Theory: Towards a Cultural Theory of Economics," *Journal of Economic Methodology* 12(3), 455-469. https://doi.org/10.1080/13501780500223783

Gombrich E. H. (1961), *Art and Illusion*, London: Phaidon Press.

Gonzalez J. W. (2013), "Value Ladenness and the Value-Free Ideal in Scientific Research" [in:] *Handbook of the Philosophical Foundations of Business Ethics*, C. Luetge (ed.), Dordrecht: Springer, 1503-1521. https://doi.org/10.1007/978-94-007-1494-6_78

Goodman N. (1978), *Ways of Worldmaking*, Indianapolis: Hackett.

Goodman N. (1984), *Of Mind and Other Matters*, Cambridge, MA: Harvard University Press.
Guala F. (2012), "Are Preferences for Real? Choice Theory, Folk Psychology, and the Hard Case for Commonsensible Realism" [in:] *Economics for Real: Uskali Mäki and the Place of Truth in Economics*, A. Lehtinen, J. Kuorikoski, P. Ylikoski (eds.), Abingdon: Routledge, 137-155.
Guiso L., Sapienza P., Zingales L. (2006), "Does Culture Affect Economic Outcomes?," *Journal of Economic Perspectives* 20(2), 23-48. https://doi.org/10.1257/jep.20.2.23
Gulick W. B. (1988), "Reconnecting Geertz's Middle World," *Soundings: An Interdisciplinary Journal* 71, 113-153.
Halsmayer V. (2014), "Review of Morgan Mary, *The World in the Model: How Economists Work and Think*," *Journal of the History of Economic Thought* 36, 380-382. https://doi.org/10.1017/S105383721400039X
Halsmayer V. (2018), "Following Artifacts," *History of Political Economy* 50, 629-634. https://doi.org/10.1215/00182702-7023590
Halsmayer V. (2019), "Artifacts in the Contemporary History of Economics" [in:] *A Contemporary Historiography of Economics*, T. Düppe, E. R. Weintraub (eds.), New York: Routledge, 157-176. https://doi.org/10.4324/9781315169194-10
Hands D. W. (2012), "Realism, Commonsensibles, and Economics: The Case of Contemporary Revealed Preference Theory" [in:] *Economics for Real: Uskali Mäki and the Place of Truth in Economics*, A. Lehtinen, J. Kuorikoski, P. Ylikoski (eds.), Abingdon: Routledge, 156-178.
Hausman D. (1998), "Problems with Realism in Economics," *Economics & Philosophy* 14(2), 185-213. https://doi.org/10.1017/S0266267100003837
Heinemann W. (2010), "Reflexionen zum Verhältnis von Text und Stil," *Tekst i Dyskurs = Text und Diskurs* 3, 145-165.
Hutchins E. (1995), *Cognition in the Wild*, Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/1881.001.0001
Klein D., Romero P. (2007), "Model Building versus Theorizing: The Paucity of Theory in the *Journal of Economic Theory*," *Econ Journal Watch* 4(2), 241-271.
Kmita J. (1985), *Kultura i poznanie*, Warszawa: Państwowe Wydawnictwo Naukowe.
Kmita J. (1996), "Towards Cultural Relativism 'with a Small R'" [in:] *Epistemology and History: Humanities as Philosophical Problem and Jerzy Kmita's Approach to It*, A. Zeidler-Janiszewska (ed.), *Poznań Studies in the Philosophy of the Sciences and the Humanities* 47, Amsterdam–Atlanta: Rodopi, 541-613.
Knorr Cetina K. (1991), "Epistemic Cultures: Forms of Reason in Science," *History of Political Economy* 23(1), 105-122. https://doi.org/10.1215/00182702-23-1-105
Knuuttila T. (2009a), "Representation, Idealization, and Fiction in Economics: From the Assumptions Issue to the Epistemology of Modeling" [in:] *Fiction in Science: Philosophical Essays on Modeling and Idealization*, M. Suarez (ed.), New York–London: Routledge, 205-231.
Knuuttila T. (2009b), "Isolating Representations versus Credible Constructions? Economic Modelling in Theory and Practice," *Erkenntnis* 70, 59-80. https://doi.org/10.1007/s10670-008-9137-7
Knuuttila T. (2011), "Modelling and Representing: An Artefactual Approach to Model-Based Representation," *Studies in History and Philosophy of Science Part A* 42, 262-271. https://doi.org/10.1016/j.shpsa.2010.11.034

Knuuttila T. (2021a), "Imagination Extended and Embedded: Artifactual versus Fictional Accounts of Models," *Synthese* 198, S5077-S5097. https://doi.org/10.1007/s11229-017-1545-2

Knuuttila T. (2021b), "Epistemic Artifacts and the Modal Dimension of Modeling," *European Journal for Philosophy of Science* 11(3). https://doi.org/10.1007/s13194-021-00374-5

Knuuttila T., Voutilainen A. (2003), "A Parser as an Epistemic Artifact: A Material View on Models," *Philosophy of Science* 70, 1484-1495. https://doi.org/10.1086/377424

Kralemann B., Lattman C. (2012), "The Semantics of Models: A Semiotic Philosophy of Science Approach" [in:] *Semantics in Data and Knowledge Bases*, K.-D. Schewe, B. Thalheim (eds.), Berlin—Heidelberg: Springer, 50-69. https://doi.org/10.1007/978-3-642-36008-4_3

Kralemann B., Lattmann C. (2013), "Models as Icons: Modeling Models in the Semiotic Framework of Peirce's Theory of Signs," *Synthese* 190(16), 3397-3420. https://doi.org/10.1007/s11229-012-0176-x

Kuorikoski J., Ylikoski P. (2014), "External Representations and Scientific Understanding," *Synthese* 192, 3817-383. https://doi.org/10.1007/s11229-014-0591-2

Leontief W. (1993), "Can Economics be Reconstructed as an Empirical Science?," *American Journal of Agricultural Economics* 75, 2-5. https://doi.org/10.1093/ajae/75_Special_Issue.2

Lisciandra C., Korbmacher J. (2021), "Multiple Models, One Explanation," *Journal of Economic Methodology* 28, 186-206. https://doi.org/10.1080/1350178X.2021.1892800

Longino H. (1990), *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*, Princeton: Princeton University Press. https://doi.org/10.1515/9780691209753

Mäki U. (1999), "Representation Repressed: Two Kinds of Semantic Skepticism in Economics" [in:] R. R. Favretti, G. Sandri, R. Scazzieri (eds.), *Incommensurability and Translation: Kuhnian Perspectives on Scientific Communication and Theory Change*, Cheltenham: Edward Elgar, 307-321.

Mäki U. (2009), "MISSing the World: Models as Isolations and Credible Surrogate Systems," *Erkenntnis* 70, 29-43. https://doi.org/10.1007/s10670-008-9135-9

Mäki U. (2009), "Realistic Realism about Unrealistic Models" [in:] *The Oxford Handbook of Philosophy of Economics*, H. Kincaid, D. Ross (eds.), New York: Oxford University Press, 68-98. https://doi.org/10.1093/oxfordhb/9780195189254.003.0004

Mäki U. (2018), "Rights and Wrongs of Economic Modelling: Refining Rodrik," *Journal of Economic Methodology* 25(3), 218-236. https://doi.org/10.1080/1350178X.2018.1488475

Mäki U. (2021), "The Field: Tasks, Pasts, Futures," *Journal of Economic Methodology* 28(1), 3-13. https://doi.org/10.1080/1350178X.2020.1868766

Magnani L. (2009), *Abductive Cognition: The Epistemological and Eco-Cognitive Dimensions of Hypothetical Reasoning*, Berlin: Springer. https://doi.org/10.1007/978-3-642-03631-6

Magnani L., Bertolotti T. (eds.) (2017), *Springer Handbook of Model-Based Science*, Cham: Springer. https://doi.org/10.1007/978-3-319-30526-4

Magnani L., Casadio C. (eds.) (2016), *Model-Based Reasoning in Science and Technology: Logical, Epistemological, and Cognitive Issues*, Cham: Springer. https://doi.org/10.1007/978-3-319-38983-7

Meskin A. (2005), "Style" [in:] *The Routledge Companion to Aesthetics*, 2nd edition, B. N. Gaut, D. Lopes (eds.), Routledge, 489-500. https://doi.org/10.4324/9780203390795_chapter_38

Mongin P. (2006), "Value Judgments and Value Neutrality in Economics," *Economica* 73(290), 257-286. https://doi.org/10.1111/j.1468-0335.2006.00501.x

Morgan M. S. (2012), *The World in the Model: How Economists Work and Think*, Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139026185

Morgan M. S. (2014), "What If? Models, Fact and Fiction in Economics," *Journal of British Academy* 2, 231-268.

Morgan M. S., Knuuttila T. (2012), "Models and Modelling in Economics" [in:] *Philosophy of Economics*, U. Mäki (ed.), Amsterdam: Elsevier, 49-87. https://doi.org/10.1016/B978-0-444-51676-3.50003-8

Müller R. (2009), "The Notion of Model: A Historical Overview" [in:] *Philosophy of Technology and Engineering Sciences*, A. Meijers (ed.), Amsterdam: Elsevier, 637-664. https://doi.org/10.1016/B978-0-444-51667-1.50028-8

Nagatsu M., Poder K. (2019), "What is the Economic Concept of Choice? An Experimental Philosophy Study," *Economics & Philosophy* 35(3), 461-478. https://doi.org/10.1016/B978-0-444-51667-1.50028-8

Nagel E. (1961), *The Structure of Science: Problems in the Logic of Scientific Explanation*, London: Routledge.

Nersessian N. J. (2006), "The Cognitive-Cultural Systems of the Research Laboratory," *Organization Studies* 27(1), 125-145. https://doi.org/10.1177/0170840606061842

Nersessian N. J. (2017), "Hybrid Devices: Embodiments of Culture in Biomedical Engineering" [in:] *Cultures without Culturalism: The Making of Scientific Knowledge*, K. Chemla, E. F. Keller (eds.), Durham–London: Duke University Press. https://doi.org/10.1215/9780822373094-006

Nöth W. (2018), "The Semiotics of Models," *Sign System Studies* 46(1), 7-43. https://doi.org/10.12697/SSS.2018.46.1.01

Putnam H., Walsh V. (eds.) (2011), *The End of Value-Free Economics*, London: Routledge. https://doi.org/10.4324/9780203154007

Reiss J. (2008), *Error in Economics: Towards a More Evidence-Based Methodology*, London–New York: Routledge. https://doi.org/10.4324/9780203086797.ch1

Reiss J. (2012), "Idealization and the Aims of Economics: Three Cheers for Instrumentalism," *Economics & Philosophy* 28(3), 363-383. https://doi.org/10.1017/S0266267112000284

Reiss J. (2014), "Struggling over the Soul of Economics: Objectivity versus Expertise" [in:] *Experts and Consensus in Social Science*, C. Martini, M. Boumans (eds.), Cham: Springer, 131-152. https://doi.org/10.1007/978-3-319-08551-7_7

Robbins L. (1932), *An Essay on the Nature and Significance of Economic Science*, London: Macmillan.

Rodrik D. (2015), *Economics Rules: Why Economics Works, When It Fails, and How to Tell the Difference*, Oxford: Oxford University Press.

Rodrik D. (2018), "Second Thoughts on Economics Rules," *Journal of Economic Methodology* 25(3), 276-281. https://doi.org/10.1080/1350178X.2018.1490441

Roland G. (2015), "Economics and Culture" [in:] *Emerging Trends in the Social and Behavioral Sciences*, R. Scott, S. Kosslyn (eds.), London: Wiley. https://doi.org/10.1002/9781118900772.etrds0091

Ross D. (2012), "Mäki's Realism and Scope of Economics" [in:] *Economics for Real: Uskali Mäki and the Place of Truth in Economics*, A. Lehtinen, J. Kuorikoski, P. K. Ylikoski (eds.), Abingdon: Routledge, 181-194.

Samuelson P. (1975), "Maximum Principles in Analytical Economics," *Synthese* 31(2), 323-344. https://doi.org/10.1007/BF00485982

Shore B. (1988), "An Introduction to the Work of Clifford Geertz," *Soundings: An Interdisciplinary Journal* 71, 15-27.

Simon H. A. (1971), "Style in Design" [in:] *Proceedings of the 2nd Annual Conference of the Environmental Design Research Association*, Pittsburgh: Carnegie Mellon University, 1-10.

Simon H. A. (1998), "Economics as a Historical Science," *Theoria: An International Journal for Theory, History and Foundations of Science* 13(2), 241-260.

Sorokin P. A. (1957), *Social & Cultural Dynamics: A Study of Change in Major Systems of Art, Truth, Ethics, Law and Social Relationships*, Boston: Porter Sargent.

Swoyer C. (1991), "Structural Representation and Surrogative Reasoning," *Synthese* 87, 449-508. https://doi.org/10.1007/BF00499820

Vromen J. (2021), "What are We Up To?," *Journal of Economic Methodology* 28(1), 23-31. https://doi.org/10.1080/1350178X.2020.1868768

Wartofsky M. W. (1979), *Models: Representation and Scientific Understanding*, Dordrecht: Springer. https://doi.org/10.1080/1350178X.2020.1868768

Weber M. (1949), "'Objectivity' in Social Science and Social Policy" [in:] *The Methodology of Social Sciences*, Glencoe: The Free Press, 50-112.