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Model-theory interaction in urban planning: A critical review

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Farshad Nourian
University of Tehran, Iran

Meisam Alipour
University of Bojnord, Iran

Peter Ache
Radboud University, Netherlands

Abstract

More than half a century has passed since the first use of models in urban planning. Most urban planners have agreed on using models either to simplify complicated systems or to make simulations of such systems in order to predict their future. There is, however, disagreement on how far such simplifications and simulations have worked toward the planners' goals and objectives. In this paper, through historical analysis, we placed the model-theory interaction into the broader scope of scientific modeling to develop guidelines applicable to the narrow field of urban modeling. Here, we developed an argument that models' applicability and meaningfulness in urban planning are primarily dependent on planning theories, that is, models and theories should move parallel to achieve all the functions and capabilities claimed by models. Thus, an interactive process shapes the model as the mediator between the theory and the phenomenon: (a) the theory explains an abstract phenomenon, (b) the model provides an understanding of that phenomenon, and (c) the original abstract explanation is revisited and made more practical. This evolutionary process is our view of the "mediator model," that is, a new definition of the urban model.

Keywords

mediator model, model-theory Interaction, theory, urban modeling

Corresponding author:
Farshad Nourian, Department of Urban and Regional Planning, University of Tehran, Enghelab Avenue, Tehran 1933744781, Iran.
Email: fnoorian@ut.ac.ir

Introduction

The work of Deutsch (1951: 1) on models in natural and social science begins with "Men think in terms of models"; known as model thinking. Based on the evolution of model thinking, as promoted by the exponential growth of ICT and sophisticated software and methods, Mark Johnson states that "most scientific research is model-based" (Magnani and Nersessian, 2002: 1). Assume that revisiting the epistemology of model thinking in both the broader scope of science and the narrower field of urban planning can enable us to understand models and model thinking. Indeed, in urban planning, an accurate definition of the "urban model" can be an appropriate response to the vital question of "why do we need models?"

Through a historical analysis in the first section of this paper, our primary aim is to inform the reader about a debate on model-theory interaction. This debate suggests that without supportive theories, models are meaningless; that is, models' calibrations, data gatherings, error delineations, iterations, and results would render useless without their supportive theories. Then, we focus on urban planning to figure out how the composition of model-theory is shaped. Finally, we offer insights into making the model application successful, constructive, and, above all, theoretically oriented more than it had been within the urban planning discipline and practice in the past.

Is the model an autonomous entity with a simple function?

The problem that this paper points to is the waning of the model's role in simplifying the real world. As Rosenblueth and Wiener (1945: 316) argue, "any substantial part of the universe can be studied solely through abstraction which consists of a model of similar but simpler structure." The argument is still valid. Some urban modelers believe that in order to understand the functions of cities, we need to simplify and abstract what we see as a model (Batty, 2013; Foot, 2017; Harris, 1965; Helly, 1975; Putman, 1975). The proponents of modeling agree on utilizing models for simplification of complex urban phenomena and simulations. In this paper, we argue that, on the contrary, simplification, and simulation are not the ultimate goals of urban modeling. Instead, they are just model's functions which, besides other functions, serve the theories to develop, construct, and test a hypothesis.

Another issue is that the urban modelers see simplification as an end. As Batty (2007: 2) puts it: "Models are abstractions, simplifications of the 'real thing'." When modelers simplify a phenomenon, they assume that they have achieved their goal by defining and classifying the parameters without regard to models' appropriateness to theories; that is, they have nothing to do with theories. Here, however, we argue that the final goal of modeling is not simplifying a phenomenon; instead, the final phase of modeling is to go back to theories and make corrections based on the model's results. We consider this as a two-way model-theory interaction.

The relationship between theory and model

How logical is it to consider the model as a complementary concept to theory? To answer that, we need to elaborate on the terms "theory" and "model." Although it is not our intention here to present an accurate definition for each term, it is necessary to know their critical semantic differences.

Let's start with theory. There is a lack of consensus on precisely what a theory is. Merton (1967: 39) argues that "the word theory threatens to become meaningless because its referents are so diverse, including everything from minor working hypotheses, through comprehensive but vague and unordered speculations, to axiomatic systems of thought."

In natural sciences, "theory is that to which we resort to when we try to describe what the world is" (Bailer-Jones, 2009: 209). Sutton and Staw (1995: 378) argue:

> *"Theory is the answer to queries of why. Theory is about the connections among phenomena, a story about why acts, events, structure, and thoughts occur. Theory emphasizes the nature of causal relationships, identifying what comes first as well as the timing of such event".*

Mandelbaum, as mentioned in Donaghy and Hopkins (2006: 175), defines theories as "particular sorts of statements which organize the vast array of causal narratives and explanation." One type of theory explains observable phenomena using causal factors. It may include reasons for value judgments and perspectives, helping us to cope with reality. Binder (2012: 238), on the other hand, argues "theories are the inevitable outcome of practice" based on our understandings of the world. March (2010: 110) writes about a fundamental difference between deductive and inductive theories.

Do we need to choose from all different definitions of "theory"? Nourian and Jaberi Moghaddam (2014) argue that each definition of "theory" is a visionary position of the theorist, especially when we consider "planning theories." A visionary position that points to one particular definition is a megalomaniacal delusion. None is better than others. This delusion grants them the arrogance to face competing theories in a manner not unlike Quixotic knights. This delusion can cause chaotic behavior among experts, especially when encountering ideas not fitting their desire.

Thus, here we tend to avoid naming a theory to be accepted by all. We can hardly expect to build consensus among theorists about the nature of urban planning and how it *should* be done. As noted, it seems that building consensus among planners is practically impossible while diversity and gap have increased (Nourian and Jaberi Moghaddam, 2014).

Nonetheless, and for the sake of having a reference point, let us consider Neuman's meaning of theory (Neuman, 2005:124–125). His definition of theory and planning theory without modifiers is general, as in a standard dictionary definition. As for "city planning theory," however, he lays out four roles: explanation, prediction, justification, and normative guidance (Neuman, 2005: 126–127). We do not intend to expand on this definition since this is not the purpose of our paper. It suffices here to say that our "model as mediator" corresponds to the above four roles with modifications.

It is not surprising that "model" is not easily defined either. Thus far, we understand that the meaning of model in natural sciences is more evident than in social sciences. Herein, one can argue that model refers to "a set of mathematical formulas that describe the behavior of a system and also to refer to any simplified representation of a complex relationship" (Magnani and Nersessian, 2002: 191).

The above reference points to only one of the broad expectations from model-theory interaction. Bailer-Jones (2009: 148) asserts that “theories are applied to phenomena only via models by filling in the properties of concrete phenomena.” Bailer-Jones (2009: 147) signifies that “it is not a theory that tells you what the world is like, but also, that is a model which is, in general, a somewhat simplified abstraction from the real world.” Architectural models and highly abstract mathematical formulations of problems follow this abstraction. One can perceive these models as idealized “paper-and-pencil” representations of real-life processes (Helly, 1975: 1). Thus, we can define a model “as a means of transforming a theory into a structure that is testable against observations” (Batty, 2017: 6). As Goodchild (2005: 2–3) argues:

> *A model is a representation of one or more processes that are believed to occur in the real world - in other words, of how the world works. A model is a computer program that takes a digital representation of one or more aspects of the real world and transforms them to create a new representation. Models can be static, if the input and the output both correspond to the same point in time, or dynamic, if the output represents a later point in time than the input.*

Finally, “a model is an interpretative description of a phenomenon that facilitates access to that phenomenon” (Bailer-Jones, 2009: 206). Adding “adjectives” to the word “model” can cause divergent meanings. We have to consider the requisites of semantic changes when we use the “urban model” in social sciences and urban planning. Foot (2017: 3) characterized the urban model to describe the urban system using mathematical equations.”

Here, we tend to use the definition of urban model as provided by Batty. He defines urban models as “the representations of functions and processes which generate urban spatial structure, usually embodied in computer programs (Batty, 2009: 51). Batty (2007: 6) also refers to iconic and symbolic models. Iconic models are built from materials similar to the material in the real world. On the other hand, mathematical structure and logical-analytical mathematics are used in symbolic models. Although these two can be complementary, our emphasis here is on the symbolic models. Examples of the contemporary symbolic models include Space Syntax, Agent-Based Modeling (ABM), and Cellular Automata (CA). Behavioral spatial interaction theory and temporally dynamism are part of the character of such models. One example is transportation modeling that incorporates big data and GIS (Albeverio et al., 2008: 12).

There are two key differences between the definition of a model in the urban field and the general field of science:

- In science, generally, the emphasis is given to the gap between theoretical view and the real world in a way that somehow model is introduced to fill that gap as a solution. Model, in serving theory, simplifies and represents the phenomena to facilitate access to it.
- In the urban field, a model is defined as being more practical. Some of its functions, such as simplification and representation, are highlighted in the definition. Urban phenomena are complex systems embedded in various forms of human societies. Such complexity includes elements such as human intelligence,

> learning capabilities, and system imbalance. The urban environment is, almost by definition, too complex to be grasped at its fullest for its interactions between various sub-systems in constant change (Healey, 2006: 228). Furthermore, the debate on planning theories never ends (Nourian and Jaberi Moghaddam, 2014).

In the following section, we re-examine the relationship between model and theory by looking briefly at the history of model thinking in pure sciences.

In the broader scope of model thinking

As discussed by Rydin (2007: 54), there is not one but multiple knowledge and ways of representing reality. Our emphasis here is on models as the mediator between theory and the phenomenon to be used in urban planning. Thus, we tend to refer to the list of shifts in epistemology in scientific approach as discussed by Bailer-Jones (2009: 205): (a) from models as physically built to models as theoretical constructs, (b) from disregarding models to allowing them space, and (c) where theories seek for means of providing scientific accounts of natural phenomena (Table 1).

For further clarification of Table 1, we can add the following points:

- ***The ancestor of models: Analogy***
  - "Some of the constructs that were referred to as analogy in the nineteenth century, we would most likely call models today. One reason why analogy is often thought to occur in science is because it supports a central function of models: explanation" (Bailer-Jones, 2009: 17, 55).
  - "The analogy has also been instrumental in overcoming the limitations of thinking of models purely as mechanical in the narrow sense of the word. Analogy helped to lift our understanding of what a model is, and of what counts as a mechanism, to a more abstract level" (Bailer-Jones, 2009: 17).
  - "The analogical model represents what is shared among the members of specific classes of physical systems, viewed with respect to a problem context" (Nersessian, 1999: 16).
- ***Rethinking: New Allies***

Although Duhemian and Campbellian's views were divergent, both harmed the model application. Eventually, a new tendency arose among scientists. The following reflects how Braithwaite, Hutten, and Hesse opted for a new scientific reputation for model thinking (Bailer-Jones, 2009: 102):

- to interpret a theory
- to visualize
- to link the unfamiliar and the familiar
- to use as descriptive vocabulary
- to guide experimentation
- to use as a tool for thinking about and developing theory

Table 1. Historical analysis of model thinking in science.

Duration/ Period	Model elements examined		
	Approaches/Scholars	Functions	Goals related to theory
1800–1900	Mechanical analogy	Abstraction representation	Formulation of hypotheses/ experimental testing/ theory development
	Mathematical analogy	Description formulation	Representation of experimental laws
1900–1940	Duhemian	Discovery explanation	"Aids" to the formation of hypotheses
	Campbellian	Translation	"Part" of the formation of hypotheses
1940–1980	Metaphor/Braithwaite and others	Interpretations	Thinking about the theory
	Metaphor/Hutten	Partial interpretations	Explain and test theory
	Mathematical model/Hesse	Discovery	Theory development
1980+	Mediator Model/ Cartwright and others	Interpretation representation	Application of theory to the world

Authors based on Bailer-Jones (1999; 2002; 2003; 2004; 2009).

"Metaphor" has been the essential outcome. This notion is reflected in Mary Hesse's assertion that a model makes appropriate vocabularies accessible in cases that we cannot represent a complete description of phenomena in the everyday language (Hutten, 1954: 286, 295–298). "A metaphor is a linguistic expression in which at least one part of the expression is transferred from one domain of application 'source domain', where it is expected, to another 'target domain' in which it is unusual, or was probably unusual at an earlier time when it might have been new" (Bailer-Jones, 2009: 111). For example, the term "footprint" in the "Ecological footprint index" denotes the meaning of "the human impact on nature." While expanding the debate on environmental impacts of human beings is too dull for many people, using the term "footprint" makes it easier to understand and deliver the right message through the image as has been shaped in the audience's mind.

Also, Hesse makes a distinction between positive, negative, and neutral analogy (Figure 1). Unlike positive analogy, the negative analogy reminds us that models can include wrong claims leading to wrong decisions. Given Hesse's idea on neutral analogy, modelers may consider the potentiality of exploration.

Models as mediator

Cartwright (1999: 1) starts her book by saying that "we live in a dappled world" and concludes that there can be a number of models for a unique phenomenon at the same time, and each theory is applied in the real world through its model. She classifies models into two categories of Representative and Interpretive: Interpretative models establish a link

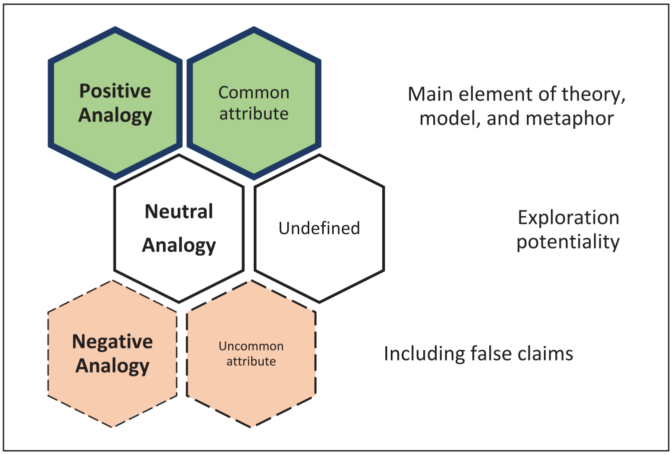

Figure 1. Different types of analogy based on Hesse (1966) by: Authors.

between abstract theory and model, whereas representative models establish the link between the model and the world (Bailer-Jones, 2009). Classification of models is valuable partly because models have a somewhat hybrid nature; that is, they are neither theory nor simple descriptions of the world. Thus, models mediate between theory and the world and intervene in both domains (Morgan and Morrison, 1999: 44).

Cartwright takes representative models as “models that we construct with the aid of theory to represent real arrangements and affairs or could do so under the right circumstances.” Interpretative models have the function of representing certain theoretical situations, and these may or may not be similar to real situations. Representative models, in turn, need not and do not have this interpretative function to “fit out” theories (Bailer-Jones, 2009: 143).

As a result, the mediator model includes both interpretative and representative models, which define additional functions for a model such as translation, abstraction, idealization, and simplification. Furthermore, we now know that theory and phenomenon possess their specific roles in modeling. Model is neither a simplified phenomenon nor an interpreted theory, but an entity that is simultaneously dependent on both and semi-autonomous (Figure 2).

Also, we need to consider the following from the literature:

- A crucial point in our literature review is the necessity of “Rethinking.” Scholars have always made an attempt at “Rethinking” what they had done as Modeling. Thus, we can cast doubt on the current view toward urban modeling – whatever it is – because Rethinking is the permanent element of the modeling process.
- Model-theory interaction should be established and strengthened. Our review shows that models cover a vast range of functions, from mere simplification to interpretation and prediction. Although the goal and the role of the model can be diverse, as a “mediator” it should cover all.

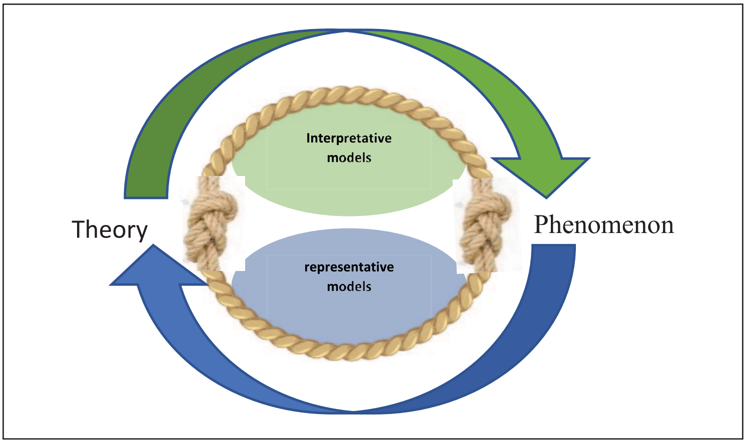

Figure 2. Model as mediator by: Authors based on Cartwright (1999) and Bailer-Jones (2009).

In the scope of urban modeling

The use of "model" in the urban field goes back to the mid-20th century when digital computers first appeared (Batty, 2017: 6). The motivation for earlier models came from the policy end of the planning spectrum (Batty, 1979: 867). Later, this evolved into modeling such as Agent-based and Cellular Automata, which deal with inherent processes of change. These are best characterized as "disaggregate" and "dynamic" (Albeverio et al., 2008: 11).

Here, we do not see the need to present a list of models, the urban theories, and the planning theories since this list is in Batty's "Fifty Years of Urban Modeling: Macro-Statics to Micro-Dynamics" (Albeverio et al., 2008). In this section, our emphasis is on the "model-theory" interaction in the urban field. We have sorted the history of such interaction into three temporal classes and have analyzed them critically.

A time to borrow

In the 1950s, the urban studies used other disciplines' models. Alonso (1971: 169) described the interdisciplinary approach in urban planning as follows: "Take a physical planner, a sociologist, an economist; beat the mixture until it blends; pour and spread." Putman (1979: 2) believed that this interdisciplinary approach, which derived from the operations research and systems analysis perspectives of the post-World War II decade, utilized other disciplines' models, even military models, in urban planning. The main model types were based on gravity, linear, and optimizing mathematics, which was deterministic and predictive rather than purely descriptive (Foot, 2017: 1, 8).

From a theoretical point of view, three perspectives affected urban modeling: (a) transportation flows and interactions, (b) notions about how populations were distributed, and (c) spatial structure and location (Batty, 2017: 7). All were used in disciplines and professions other than urban planning. Eventually, cities became the new objects of experimentation. For instance, Wilson (1970: 255) investigated "a more than a usually systematic appraisal of the Newtonian gravity model" to integrate it into the input-output framework. Reilly's model, Lowry models, Gravity/Entropy-Maximizing Models, linear programming are some more examples (for more information, see Harris (1965), Foot (2017), and Helly (1975)). Sayer (1976: 192), in "A critique of urban modeling," explains:

> *"Many spatial models, including those with no explicit economic content, use the same methodology as neoclassical economics. . . .. This shared methodology is perhaps the clearest in the case of entropy-maximizing or gravity models and neoclassical utility theory"*

Initially, planners were delighted to utilize models in planning so much that Harris (1965) labeled models as "new tools for planning." As in a laboratory setting, the scientist-planner made observations on urban phenomena as subjects of experimentations, wearing a pair of eyeglasses (i.e. the theoretical view) and using lab instruments (i.e. models) (Figure 3). It took them a decade to notice that neither a complex city environment is similar to a lab setting nor models are lab gadgets like pliers that are used for gripping objects. This is discussed further in the next section.

Failure

First doubts on urban modeling showed up a decade after it was first introduced in planning. Batty (1979: 864) points this out as "continual call for a paradigm shift, for a new way of looking at things."

The first step in "rethinking" urban modeling was the disapproval of models. Putman (1979) has confirmed this "downvoter" by reporting the anti-urban-modeling sentiment by the mid-1960s, which began to appear amongst planners and policymakers (p. 3).

From the theoretical standpoint, Lee (1973) described not just urban modeling but also urban planning theory as a disputed subject. In "Requiem for Large Scale Models," he states that "Lacking a coherent body of theory, the modelers turned to analogies and descriptive regularities. The untested hypotheses of various social science fields were accepted uncritically and merged without establishing the validity of either the individual relationships or the combined structure" (1973: 169).

Also, Sayer (1979: 857), who used the term "trap" to express what urban modeling and regional science tended to fall into, pointed to the wrong "assumption that what it takes to be the methods of natural science can be applied straightforwardly to social science." Flyvbjerg (2001) also argued that the existence of natural science theory is entirely distinct from social science theory and asserts that "Context and judgment are irreducibly central to understanding human action" (p. 4). Models in economics and engineering fields neglect concepts such as amenity, livability, and dignity, which are often considered in planning (Harris, 1988: 523). As a consequence of these criticisms, Putman (1979: 4) says, "the backlash of the late 1960s brought most large model projects to a stop for several years." By 1973, the early modeling efforts had been abandoned (Klosterman, 1994b: 4).

On the interaction of models and theories, Batty (1979: 863) pointed to the theory's deficiency and the disablement of practice. Lee (1973: 169) warned the modelers that the amount of supportive theories available is nowhere near sufficient. Finally, Sayer (1979: 860) argued that the main problem is the inadequate understanding of the nature of theory in the studies of society. In summary, the "interaction with theories" was the weakness that those thinkers pointed out as the root of the problem in the urban modeling.

Standing up again

Pack and Pack (1977: 407) in "The Resurrection of the Urban Development Model" show a return to model use in planning agencies after the failures of the 1960s. Putman (1979), Boyce (1988), and Harris (1988) saw this resurrection as a renaissance and a rebirth of large-scale modeling. It was now time for different groups of scholars to react.

The first group: Advocates of the tradition. This group includes those who advocated the use of models as borrowed from other disciplines. They believed that faulty outcomes are due to factors outside the modeling itself, such as poor calibration and data limitation. In Klosterman's (1994a: 42) point of view, setting up a model with poor data quality is more of a problem than deficiencies in the model structure. Also, Klosterman (1994b: 4) quotes Britton Harris, who critically responded to Lee's "seven sins of large-scale modeling," arguing that progress in computer technology has neutralized many of those sins. Therefore, in this group, efforts were focused on modifying the model at the construction phase.

Using the traditional modeling, McFadden (1974) represented an advanced travel demand model, and Anas (1982) continued to work on the integration of Lowry-type and economic-theory-based models. According to Harris (1994: 33), computer and data availability were the factors that could help urban models and provide more accurate results. Thus, the first group followed the tradition; but they did not make any effort to address the model-theory interaction.

The second group: Scientific reformists. Reformists, who were also loyal to the scientific method as those in the first group above, had a more in-depth view of urban modeling and tried to rethink modeling in a scientific manner beyond the process of model construction. For example, Boyce (1984: 1445), as a reformist, argues that "The 'model building' activity suffered enormously from the lack of a rigorous scientific approach, and in particular, from an inability to formulate the problems requiring solution." Such scholars believed that setting up a model, as practiced in natural or pure sciences, is not the root of models' weaknesses; instead, the problem is rooted in the way we apply it. Both Klosterman (1994a: 42) and Boyce (1988)

> *moved from the "art", of large-scale modeling of the 1960s to a "science", of modeling. The scientific support gave them the confidence to state that "The use of mathematical models is the only practical way of predicting the effects of urban policies on the interaction between land use and transportation"* (Paulley and Webster, 1991: 197).

Scientific reformists, however, faced a significant limitation: the disability in addressing the complexities associated with the subjects, the cities, and the social phenomena. To this, Batty (2017) adds the ethical dimension.

Table 2. Historical analysis of the urban modeling.

Period	Model elements examined		
	Approach	Function	Goals related to theories
1950–1960	Non-urban models: Batty, Foot, Putman, Wilson, Harris, Helly	Prediction	Application of scientific models through replication of urban variables
1960–1973	Anti-modeling: Sayer, Lee, Flyvbjerg, Binder	–	–
1980+	Rethinking – traditionalist: Klosterman, McFadden, Harris	Prediction	Modification of model at the construction phase
	Rethinking – Scientific reformist: Batty, Boyce, Paulley	Simplification, simulation, prediction	Translation of other theories through programming and mathematization

Authors' compilation.

Later, scientific reformists attempted to present a solution to the above limitations: computer programming and computer modeling. Klosterman (1994b: 3), for example, notes that "[g]iven changes in society, planning, and technology, it seems appropriate to re-examine the use of computer models in planning." Using computers was "dream come true" for some urban modelers.

Batty (1976: 6) maintains that computer environment acts as a surrogate for the laboratory setting. Urban models are thus essentially computer simulations that translate theory into a testable form without experimenting on the real thing. As a result, computer programming plays the role of urban modeling's language through which theories could be imported to the field through a translation process into mathematics. Klosterman (1994a: 42) asserts that Wilson's (1974) "Urban and Regional Models in Geography and Planning" provided comprehensive modeling text for modelers with more advanced mathematical backgrounds. He believed that using mathematical representation of catastrophes, chaos, complexity, and non-linear dynamics could lead to further advances in urban modeling (Harris, 1994: 33). It was argued that there is a strong correlation between the level of mathematical training and ability of the researcher, on the one hand, and the quality and significance of the results obtained, on the other (Boyce, 1984: 1467).

Table 2 presents the views of both the traditionalists and the reformists at different periods. It can be concluded, based on Kuhn's (2012) notion of "Scientific revolution," that "a time to borrow" was the period of almighty dominance of the model application. This machine, however, failed; and later, computer simulations tried to get the machine moving again.

The "urban mediator model"

Batty (2009: 51) defines urban model as "a representation of functions and processes which generate urban spatial structure." Although we accept this definition, we add that representation is only one of the model's diverse functions.

Figure 3. Metaphoric description of model building at "A time to borrow" era by: Authors.

As mentioned before, the literature refers to other reasons to use models. One reason is the interaction between realism and simplification, which leads to understanding (Albeverio et al., 2008: 40). Such interaction can also be found in the "Model Cities," written by Batty (2007: 5). He writes about the interaction between reality and models by separating reality into the past and the future. Here, we suggest focusing on the model as a "mediator" which may (a) describe an urban phenomenon, (b) describe plausible and probable futures (instead of making absolute predictions), (c) make judgments, and (d) guide values.

We argue here that such understanding helps us to use modeling for theorizing in planning. Our "urban mediator model" can affect both theory and the phenomenon for a better cognition of complex systems and strengthening of theoretical views. "Urban mediator model" describes urban phenomena through a variety of functions such as simplification, simulation, and idealization in order to redefine, re-inspect, or reconsider planning theories.

We start with the idea that a model not only tests a theoretical hypothesis but tests the theory itself. A theory that explains a phenomenon is tested and verified using the understanding that a model provides from that phenomenon. In these terms, an interactive process is formed: (a) the theory explains an abstract phenomenon, (b) the model provides an understanding of that phenomenon, and (c) the original abstract explanation is revisited and reviewed.

Let's consider an example: based on a theoretical framework and within the Agent-based Model (ABM), the traffic flow can be metaphorically described as a flow of a liquid on a given surface. Knowing the characteristics of traffic flow through modeling – such as drivers' learning abilities and awareness of the environment – one can understand the differences between the abstract theoretical explanation and the actual phenomenon. The urban model, however, informs that the theory needs to be refined in terms of the agents and their weights. At this point in theorizing, the driver whose objective is to reach his/her destination in a shorter time and drives through back alleys instead of the main arteries needs to be studied further to understand his/her behavioral rules better. This cyclical process in rethinking the theory continues until the urban planner can better understand the phenomenon, leading to the theory's evolution. This process is shown in Figure 4. In this process, the ultimate goal is not merely to understand the phenomena but to strengthen the planning theory.

Requiem for those models that have lost their theories

If we consider the model as a physical body, the theory is the spirit within. If the theory loses its credibility, the model would have no chance of survival (Figure 5). This argument is in line with Bailer-Jones (2009: 82), that "Models are mainly of temporary benefit; they come and go, while theories last." For example, if we did not perceive the city as a mass under dominant "Gravity Theory," we could not use Riley's model to define the city's territory. If we had rejected "functionalism" and "zoning" then, we could not estimate future travels through Origin-Destination's models. Without theory, we could not know whether a model works or not. Similarly, we would not be able to use models to empower a particular paradigm or shift to a higher knowledge base level.

Urban modelers-planners interaction

Although our argument (similar to Bailer-Jones, 2009: 152) positions models between theories and phenomena, they are not autonomous agents because they are subject to constraints from both the theory and the phenomenon. Thus, strengthening model-theory interaction in urban planning needs the urban modelers, the planning practitioners (such as researchers, stakeholders, politicians . . .), and the theorists in dialog and joint action. The urban modelers should ask the planning practitioners to look for theories that can support practice. The planning practitioners should ask the modelers to refine the tested model to link theory with practice within an urban context. The theorists use the outcome of this part of dialog to explore and refine his/her theory. Thus, the "model" functions as means to explore, build and apply theories through constant exchanges between the three actors.

Thus, "Model-theory interaction" does not mean that models can compensate for lack of theory. For the model to act as a mediator means that models need to relate phenomena to the theories and not merely make a judgment on them. Although the model, the phenomena, and the theories act together, they have distinctive functions.

Also, the "urban mediator model" may act as a tool for knowledge diffusion: the transformation of abstract knowledge into a concrete application. Mediating between planning theories and urban phenomena is to fill a theory-practice gap in planning.

To go back to the theories of/in planning (Faludi, 1973) and simultaneously look at the necessity of the model-theory interaction, we need to synchronize the categories of planning and related categories of models (for instance, process models and flow models). This synchronization means that the urban modelers can work with both procedural

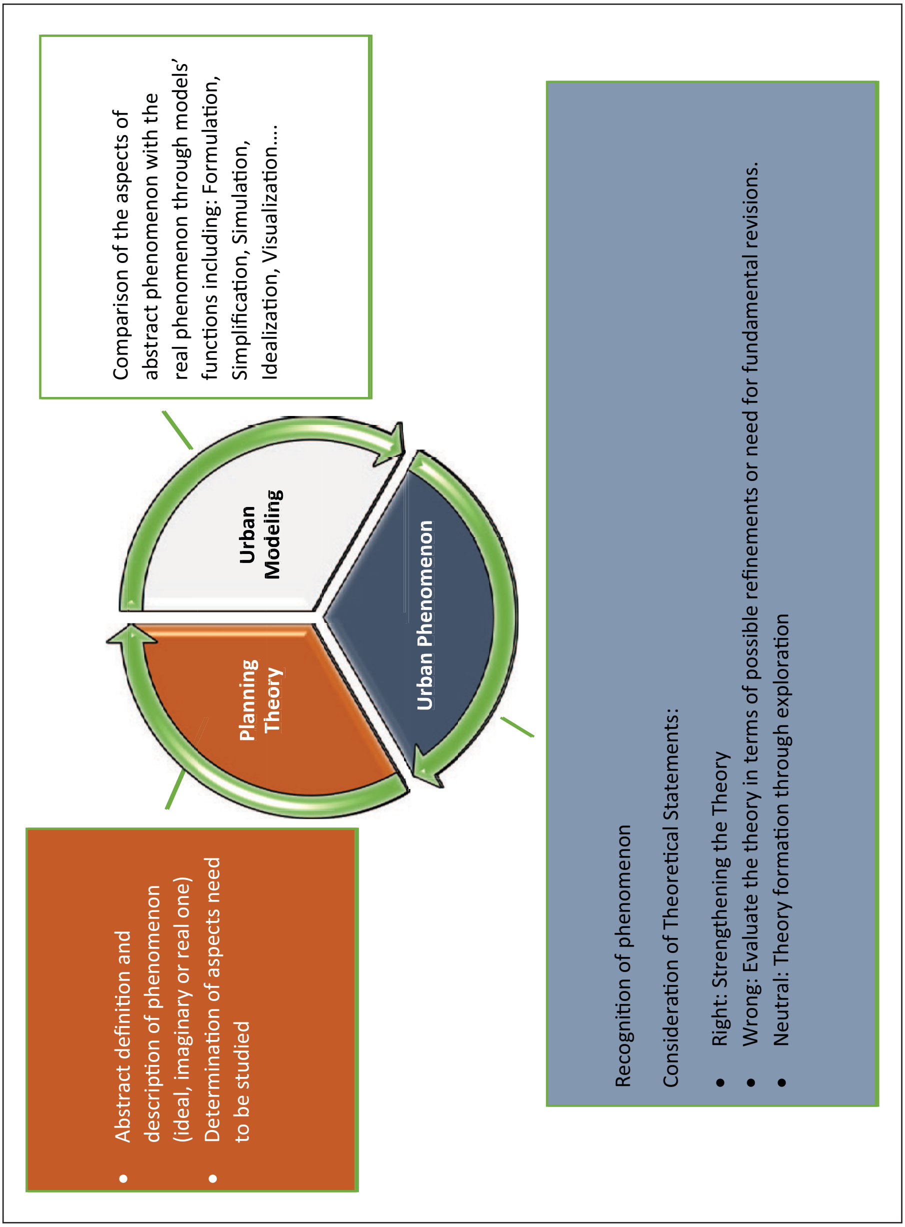

Figure 4. The urban mediator model by: Authors.

Figure 5. Theory-less modeling by: Authors.

and substantive theories. Modeling the urban phenomena needs substantive or normative theories. Thus, although models come and go in history, the "model thinking" remains constant. This model thinking can help the model-theory interaction, keeping an eye on the phenomenon.

Essential skills: "Metaphor" and "Analogy," building

"In essence, the first thing that had to be done in building computer models involved the learning of new skills" (Batty, 1979: 867). Using metaphors and analogies, as sub-processes of modeling, can also be perceived as a practical skill for urban modelers in their dialectic with planning practitioners and theorists on the interaction between model, phenomenon, and theory.

Metaphors and analogies are not models by themselves; however, they can smooth out the modeling process. The metaphorical approach in modeling is the function that brings modelers, planners, and theorists together, providing standard vocabularies from the source domain. An example of using metaphor in the planning field is the work of Talvitie (2009), who has used the psychoanalytical approach and its jargon to solve a planning problem. Since "we see things differently because words, phrases, expressions, objects are interpreted differently according to our frame of reference" (Healey, 1992: 152), the metaphor would effectively fill the gap between the planner as a specialist and the public. This can be traced back to theories such as interactive planning and communicative planning, involving stakeholders, and consensus-building. Eventually, this can expand the professional knowledge amongst the community members, as the metaphor of “Ecological Footprint” has done. Given the importance of dialog and discourse in the planning process (Also see Innes, 1998; Fischler, 2000), the metaphor can play a dominant role in the communicative action.

The point we want to draw from the analogical approach is the usefulness of neutral and negative analogy, which has been neglected in urban modeling. If positive analogy referred to typical attributes of the phenomenon in an established model, the negative analogy contains those model’s properties that cannot be found in the real world, leading to false claims (Bailer-Jones, 2009: 193, 209). As a result, urban modelers should be cautious about false claims they could insert into models. Appropriate false claims, however, could play an essential role in bridging the gap between the phenomenon and the theory.

The neutral analogy can also be used for exploration. Model builders can re-analyze those attributes that could not fall into positive and negative classes of analogy.

Prediction is not a goal for models

As mentioned in this paper, urban systems are highly complex and nondeterministic, meaning that one can easily question the notion of prediction. Thus, over-emphasizing the role of prediction in modeling could be fatal to urban models’ prospects. As has been frequently said, models are neither true nor false. Modelers need to give priority to finding patterns over mere prediction. The emphasis should be put on recognizing plausible and possible futures, not on the description of an absolute future in detail.

Hence, the modeling process should deal with theory and the phenomenon instead of focusing on issues such as model “calibration” and statistics. Notably, in the urban field, which Talvitie (2009: 185) describes as “Non-ergodic” meaning unpredictable; we should avoid using models exclusively for predicting future developments. Instead, models could serve as a tool in scenario planning for exposing drivers and uncertainties or as means of studying particular aspects of planning interventions in order to gain an overall picture of drivers, which may or may not emerge as result of those interventions.

Conclusion

Here, we tried to look comprehensively at model-theory interaction. We aimed at providing insight in applying urban modeling along two dimensions: opportunities related to the strengths of scientific modeling and weaknesses in urban modeling experiences. We placed the model-theory interaction within the broader scope of scientific modeling to develop guidelines that could be applied to urban modeling. We argued that the models and the theories should interact to gain the benefits of modeling. An interactive process shapes the model as the mediator between the theory and the phenomenon such that the theory explains an abstract phenomenon; then the model provides an understanding of that phenomenon; and finally, the original theory is revisited and made more practical in the urban settings. Metaphors and analogy could help in this evolutionary process. Our view of an "urban mediator model" could motivate urban modelers, planning practitioners, and urban theorists to rethink the role of models in theory development as well as the role of theories in the empowerment of modeling, filling the gap between theory and practice.

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ORCID iDs

Farshad Nourian https://orcid.org/0000-0003-2286-9738
Meisam Alipour https://orcid.org/0000-0003-0003-238X

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