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TOWARDS A THEORY OF MULTI-METHOD M&S APPROACH: PART III

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ABSTRACT

The current level of theoretical, methodological, and pragmatic knowledge related to a multi-method modeling and simulation (M&S) approach is limited as there are no clearly identified theoretical principles that guide the use of multi-method M&S approach. Theoretical advances are vital to enhance methodological developments, which in turn empower scientists to address a broader range of scientific inquiries and improve research quality. In order to develop theoretical principles of multi-method M&S approach, the theory of falsification is used in an M&S context to provide a meta-theoretical basis for analysis. Moreover, triangulation and commensurability are characterized and investigated as additional relevant concepts. This paper proposes four theoretical principles for justification of the use of a multi-method M&S approach, which will be analyzed and used to implement methodological guidelines in a subsequent work. A final discussion offers initial implications of the proposed theoretical view.

1 INTRODUCTION

Multi-method M&S has a long history with varied applications. Fahrland (1970) suggested application of both discrete and continuous methods to model different parts of systems. For instance, in batch-processing at a chemical plant, a discrete process could help investigate policies that pertain to scheduling, inventory and resource use, while a continuous view of chemical reactions could describe mass balance. In automobile traffic problems, queuing and driver decisions would be discrete, while vehicle dynamics continuous. In neuro-muscular systems, task sequencing and impulses would be discrete, while muscle mechanics and biochemical reactions continuous. Using an approach with multiple methods has gained momentum in recent years. It has already been used to represent various phenomena in manufacturing (Rabelo et al. 2003); healthcare (Brailsford, Desai, and Viana 2010, Chahal and Eldabi 2008); supply chain systems (Balaban and Mastaglio 2013, Lee et al. 2002); and military (Balaban et al. 2014). For instance, Discrete Event Simulation (DES) and System Dynamics (SD) methods often complement each other where DES offers better representation of detail complexity, while SD allows for easier representation of dynamic “feedback” effects (Chahal 2010, Morecroft and Robinson 2005).

Balaban, Hester, and Diallo (2014a) offered their philosophical stance about the main terms in the context of using more than a single method within the M&S field. They defined multi-method M&S as an approach that consists of at least two modeling methods, where at least one of them is an M&S method. The term “M&S method” combines elements of both a modeling method and simulation under a single term. Balaban and Hester (2013) identified various purposes for the use of a multi-method M&S approach such as complementarity of methods, multilateral problems, unique representation, data availability, validity, triangulation, and emergent phenomena. Despite the appeal of using multiple M&S methods to represent various phenomena, it is problematic that the possible reasons and justifications for doing so have not been thoroughly explored to provide a solid theoretical basis. The current theoretical basis to conduct a multi-method study is limited, which is also visible through limitations of methodological guidelines. Overcoming these limitations is vital to enhancing the application of M&S to a broader range of scientific inquiries, improve quality of research, and finding common ground between scientific domains. This work proposes theoretical principles to guide a multi-method M&S approach.

Padilla et al. (2011) said that “M&S is the study of conceptualizations, their theory, analysis, design, efficiency, implementation, validity and verification, and application” (p. 162). Because M&S process can be also used for theory building (Smith and Conrey 2007), in order to investigate theoretical principles of a multi-method M&S approach, a higher order of analysis should be considered. According to Adams and Buetow (2014), it is helpful to use a background theory as a starting point for further inquiry that is sufficient to provide basis, but it is even more desirable to reach beyond background theories toward a grand theory roots for a major enquiry research. Theory of falsification developed by Popper (2002) will be introduced next as a grad theory providing theoretical basis of this work. Next, concepts of triangulation, complementarity and commensurability will be characterized in the context of identifying justification principles for the use of multi-method M&S approach. Finally, the paper offers discussion in the context of proposed theoretical principles and ends with the necessary follow up research.

2 THEORETICAL BASIS

This section introduces and uses concepts of falsifiability, commensurability, complementarity of methods, and triangulation to propose justification principles for use of a multi-method M&S approach.

2.1 Theory of Falsification

According to Popper (2002), a statement is falsifiable if it is possible to conceive of an observation or an argument which proves the statement in question to be false. Popper (2002) discussed types of statements and their relation to falsifiability and verifiability (see Table 1).

Table 1: Types of statements according to Popper (2002)

Type of statement	Example	Falsifiable?	Verifiable?
Numerically universal statement	Of all human beings now living on the earth it is true that their height never exceeds 8 feet	No (within space and time region)	Yes
Strictly or purely universal statement	All ravens are black	Yes (any place and time)	No
Strictly or purely existential statements	There are black ravens/ there exists at least one black raven	No (no empirical/ metaphysical)	Yes
Negations of strictly existential statements	There is no perpetual motion machine	Yes (any place and time)	Yes

Specific or singular statements refer only to a finite class of specific elements within a finite individual spatio-temporal region and because of that they are considered not falsifiable. Moreover, universal statements refer to any place and time, hence they are falsifiable, and for the same reason they are not verifiable. On the other hand, strictly existential statements cannot be falsified, but can be verified. According to Popper (2002), no singular statement can contradict the existential statement because they are limited to space and time: “We cannot search the whole world in order to establish that something does not exist, has never existed, and will never exist” (p. 49). It can be noted that negation of a purely universal statement is always equivalent to a strictly existential statement and vice versa. Because scientific theories are formed from statements that can be evaluated false, they must be accepted or rejected by scientists.

Definition 1 *A potential falsifier is a basic statement that can be falsified (evaluated as false).*

A theory can be falsifiable to various degrees depending on chosen potential falsifiers. It must be at least theoretically possible to question potential falsifiers so that they can come into conflict with observation. If choices of methods can be shown inferior based on a required degree of falsifiability, the ability to choose more adequately would make a research design more objective. For instance, ABM may be more falsifiable than DES if used to capture complex phenomena beyond DES’s passive entity capabilities. Less falsifiable would mean a more predictable and less variable description of phenomenon, but less probable as a sufficient outcome of phenomenon representation if a higher degree of falsifiability was desirable. Popper (2002) provided an example of deducibility relations between the following four statements:

A. All orbits of heavenly bodies are circles.
B. All orbits of planets are circles.
C. All orbits of heavenly bodies are ellipses.
D. All orbits of planets are ellipses.

Statement A has the highest degree of universality and precision, and all other statements follow from it. Moving from A to B universality decreases “because the orbits of planets form a proper subclass of the orbits of heavenly bodies.” (p. 106). Because circles form a subclass relation with ellipses, when moving from statement A to C, precision decreases. When moving from statement A to statement D, both universality and precision decrease. B has higher precision than D, and C has higher universality than D. If B, C, or D is falsified, then so is A. A statement with a higher degree of universality or/and precision consists of a greater empirical content, referred to as a higher degree of falsifiability.

Definition 2 *Degree of falsifiability is defined by universality and precision of potential falsifiers.*

Even though a pragmatic view on multi-method M&S is necessary, achievement of higher objectivity through a better understanding of subjective dimensions with a set of transparent potential falsifiers is considered paramount. Hester and Tolk (2010) defined modeling as a process of abstracting, theorizing, and capturing the resulting concepts and relations in a conceptual model. If modeling is a process of abstracting elements of a system there are neither a perfect a nor one hundred percent accurate representation of that system. In M&S a model content can be described by its scope and level of detail (Robinson 2007). In the context of M&S, this work adapts Popper’s universality as the scope i.e. the boundary of the model, while precision as a level of detail. The level of detail is further described by accuracy, precision, and resolution. Accuracy is defined by Joint Committee for Guides in Metrology (JCGM) as a degree of closeness of the measurements of a quantity to that quantity's actual value (JCGM 2008). Similarly, Gross (1999) defined accuracy as the degree to which parameters and variables within a simulation model conform exactly to reality or to some chosen standard or referent. Precision can be viewed as units of simulation trajectory (related to time), parameters and variables, and, when considering stochastic simulation, it can pertain to an analysis of stochastic output (Law 2007), e.g. measured by variance (Gross 1999). Resolution is a degree of detail used to represent aspects of the real world or a specified standard or referent by a model or simulation (Gross 1999). In order to determine the relations between statements in the context of falsifiability, a gain of falsifiability is defined as shown in Definition 3.

Definition 3 *Gain of falsifiability (GOF) is a difference between higher and lower degree of falsifiability.*

Modeling is a mental process that uses a modeling method to develop a model by abstracting elements of reality. Because there is neither a perfect nor a one hundred percent accurate representation of a system, there are often possible multiple methodological choices including the choice of different M&S methods or their combinations. This introduces the idea of a desirable degree of falsifiability. The known fact in M&S is that there exist no perfectly valid models, yet models can be sufficiently valid for a given purpose. The concept of sub-falsifiability score is proposed next in the context of a desirable level of falsifiability.

Definition 4 *Sub-falsifiability score is a partial degree of falsifiability, evaluated in relation to characteristic(s) defined by a potential falsifier(s) reflecting desirable degree of falsifiability.*

In order to estimate sub-falsifiability score one needs to develop a set of potential falsifiers for evaluation. The potential falsifiers in the context of M&S method choice are falsifiable statements that describe the requirements for selection of method(s) adequate in the context of desirable degree of falsifiability. Degree of falsifiability originates based on the purpose of study.

Falsifiability of method can be divided into internal and external falsifiability. Internal method falsifiability is conceptualized as a characteristic of a method that describes if a method can facilitate achievement of research objectives as seen by a modeler. For instance, if a method could not represent a phenomenon or a system with a required degree of falsifiability it would not yield a sufficiently valid simulation model. This in turn would not allow an individual to answer research question(s) based on conducted experiments. Such a situation could be translated as an insufficient falsifiability of method expressed in Popper's terms as both inability of a method to represent system or phenomena at desirable level of universality, and its insufficient precision. External method falsifiability as seen by the scientific community or stakeholders relates to credibility of the study in the context of deliberation about the quality of study in the context of a method or methods employed, and considerations about a method or methods that could have been used instead. The external method falsifiability is more subjective. The often-qualitative external falsifiability (although triangulation can be used to support it quantitatively) requires confirmation from scientific communities. The multidisciplinary character of the M&S field makes this requirement more problematic because currently there are no agreed upon mechanisms for communicating subjectivity.

2.2 Complementarity and Triangulation in the Context of M&S Methods

Mingers (2001) points at two main reasons for using a multi-method approach: "It is both desirable and feasible to combine together different research methods to gain richer and more reliable research results" (p. 243). Respectively, these two reasons can be associated with complementarity and triangulation.

The concept of complementarity of methods originated from complementarity theory postulated by Bohr (1928). Mingers (2001) refers to the principle of complementarity in which "no one paradigm is superior, but that their individual rationalities should be respected within the discipline as a whole"(p. 241) In M&S context, it is often given in the context of justification for the use of more than a single method. The general idea behind the complementarity of methods pertains to taking advantage of individual method strengths and mitigation of their weaknesses. Balaban, Hester, and Diallo (2014a) proposed a more elaborate definition of complementarity as a purpose for using different methods within mental, analytical or simulation space to enhance the expansion of studied phenomena or systems inward (generalization and refinement), enhance the expansion outward to combine different phenomena or systems (scope), or enhance comparison. The question arises as to whether or not complementarity of methods could be positioned as an overarching reasoning for the use of more than a single method.

Greene (2007) described triangulation as a strategy for increasing the validity of evaluation and research findings used to investigate the same phenomenon with an intent of convergence. Denzin (1970) specifies four types of triangulation: data triangulation, investigator triangulation, model/theory triangulation and method triangulation. Balaban (2015) identified and analyzed different dimensions of triangulation in M&S as a guidance on how these dimensions could affect credibility of M&S triangulation research. A term pseudo-triangulation was defined as a type of triangulation conducted by the same individual who conducts the original research. Triangulation can be evaluated by its permitted variability and achieved convergence. Convergence as it pertains to a concept (theory) depends on process of creating compared items which delineates permitted variability in M&S triangulation affecting overall gain of credibility. The question is how different M&S methods can be used during triangulation and pseudo-triangulation studies to further increase credibility of M&S research.

2.3 Commensurability

Kuhn stated "…that men who hold incommensurable viewpoints be thought of as members of different language communities and that their communication problems be analyzed as problems of translation" (p. 175). The measure of commensurability is in large part still a philosophical concept that is difficult to assess or even describe, but it can offer an additional interesting perspective on multi-method M&S approach, hence the authors attempt to define it for the purpose of this work.

One can compare things or phenomena to search for similarity, differences, and a mix of both. The value of similarity and difference often depend on the context. If something is similar in a given context, it is often not different and vice versa, although crisp boundaries are not always easily distinguishable and this situation is called fuzzy. Commensurability reflects ability to compare at language level. The context of comparison can be the language itself, which could provide value if more precisely stated in relation to the purpose of comparison. For instance, if comparing languages pertains to the purpose of comparing theories (models) arising from the language, commensurability can be analyzed in the context of closeness between theories in relation to the languages that were used to describe them. If comparing languages pertains to the purpose of expanding theory that have better potential for closeness of theory (model) to system or phenomena, then commensurability can be better analyzed in the context of language uniqueness. The first purpose aligns with triangulation, while the second with complementarity. The purpose of complementarity of methods is used for expansion, while if triangulation produces the same results, one can say that confirmation produced view of phenomena that is more credible (Balaban 2015). In the situation when different methods continuously produce the same or very similar results based on the same situation, it may be claimed to some degree that the measures arising from different methods are suitable to triangulate given situation (Ghrayeb, Damodaran, and Vohra 2011). This way one could approach confirmation of correctness of triangulation of a given method/measure. On the other hand, if a triangulation study produces some differences, the expanded view based on differences in results necessitates further investigation. Because the differences in methods could cause different results, the comparison of methods would be a part of explaining the differences in produced theories.

Uniqueness of methods dominates region of commensurability that is characterized by complementarity (expansion), while convergence of theories dominates region of commensurability that is characterized by triangulation. Ability to point to methods' uniqueness and theory convergence is a convention for differentiation between meaning of commensurability in relation to the context of its purpose, i.e., ability to compare at the language level. Finding uniqueness in the context of lack of similarity can be misleading and vice versa. Lack of similarity does not guarantee uniqueness, and lack of uniqueness does not guarantee similarity. The distance between these extreme poles is what makes the gray area so large.

The difference between commensurability of models (e.g. a theory) and commensurability of methods will be explained first. As a convention, these terms are given here opposing meaning because of their different purposes. Commensurability of models pertains to commonality of language that permits or does not permit one to compare models (theories). Kuhn (1982) described incommensurability using the phrase ‘no common language’, as “…theories are incommensurable is then the claim that there is no language, neutral or otherwise, into which both theories, conceived as sets of sentences, can be translated without residue or loss.” (p. 670) Because a method is a form of a language (Tolk et al. 2013), the phrase ‘no common language’ can be stated as ‘no common method’. The commensurability as stated originally by Kuhn (2012) means that different methods can produce sentences that are incommensurable because of translation problem (leading to misinterpretation). From this perspective, methods that are more similar could produce sentences, in relation to a theory, that are more similar and incommensurability of two models representing the same theory should be less probable given that these theories are meant to be the same (converge). A notion of commensurability of methods is proposed at one level higher over the commensurability of a model. If the previous logic is applied, one can translate commensurability of methods into a ‘common language of method’. If one considers choosing method(s) from a set of methods, determination of their commensurability could pertain to their characteristics and ability to find common language that consists of sentences that would allow finding their required unique characteristics. If the goal of comparison of methods is to choose a method or a set of methods, potential falsifiers that compare methods’ characteristics should focus on their uniqueness in the context of study purpose. From this point of view if methods have unique characteristics they would be more comparable hence more commensurable. The difference between commensurability of models and commensurability of methods relates to the purpose of convergence (triangulation) versus the purpose of expansion (complementarity). Using this perspective, when methods possess their necessary unique characteristics this will be considered as methods that are more commensurable, but may not necessarily imply less commensurable models of the same theory. When methods are more alike for a given purpose implies better chance for commensurable models of the same theory, but does not focus on unique characteristics of methods. This leads to a definition of commensurability of methods and models.

Definition 5 *Commensurability of methods and models are characteristics that determine existence of potential falsifiers allowing for either complementarity of methods, triangulation, or both.*

The relationships between GOF for methods M1 and M2 and commensurability are proposed in Figure 1. The shapes of the graph are assumed for illustration to display decrease and increase of GOF along the commensurability axis for models and methods, respectively. The problem surfaces with the practical aspects of measuring GOF, and commensurability of models and methods, which may be subjective because they depend on developed potential falsifiers and their evaluation.

Commensurability of methods as an ability to compare can be estimated based on unique characteristics of methods, more precisely the degree of difference between alignments to a potential falsifier for compared methods. It can be calculated as an absolute difference between potential falsifier scores of two methods. The larger difference between the methods characteristics means they are more distinguishable, hence more commensurable methods. Similarly, if methods are more similar for a given criterion they are more difficult to distinguish, hence lowering commensurability of methods score.

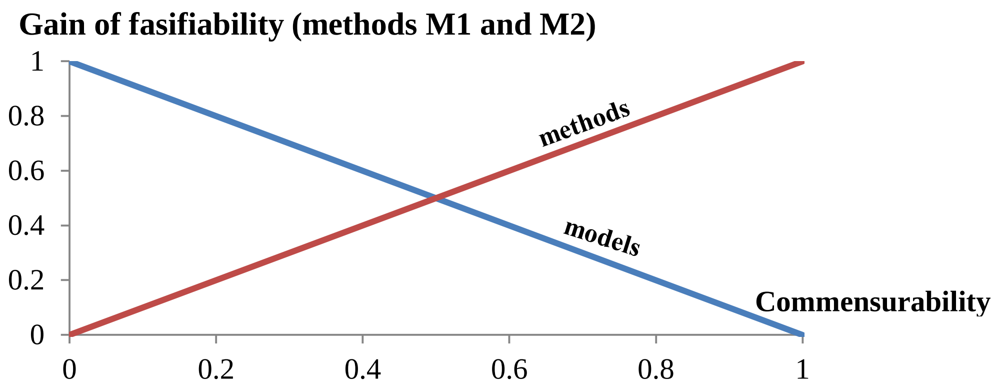

Figure 1: Conceptualization of relationship between gain of falsifiability and commensurability (models and methods)

3 MULTI-METHOD M&S PRINCIPLES

This section proposes theoretical guidelines for justifying the use of a multi-method M&S approach. Introduced earlier complementarity, falsifiability, commensurability, and triangulation are building blocks of these principles.

Definition 6 *Complementarity of methods score (CoMS) is a gain of sub-falsifiability score calculated as a difference in sub-falsifiability scores between more adequate and less adequate methods for a given potential falsifier or a set of potential falsifiers.*

A scale for CoMS is shown in Table 2. Its purpose is to give a simple qualitative degree of justification to different configurations (methods considered) allowing for evaluation of methodological quality of M&S research.

Table 2: Scale for CoMS.

Degree of justification	CoMS Value	Description
None	CoMS = 0	There is no gain of sub-falsifiability when considered methods are used together
Minimal	0 < CoMS ≤ 0.25	A gain of sub-falsifiability is minimal when considered methods are used together
Moderate	0.25 < CoMS ≤ 0.5	A gain of sub-falsifiability is moderate when considered methods are used together
Significant	0.5 < CoMS ≤ 0.75	A gain of sub-falsifiability is significant when considered methods are used together
Critical	0.75 < CoMS ≤ 1	A gain of sub-falsifiability is critical when considered methods are used together

Other views for CoMS scale e.g. fuzzy numbers scale could also be considered in the future research. Clearly, in order to use the principles, it is necessary to develop a technique(s) that implements estimation of CoMS.

3.1 Justification Principle 1

If a higher degree of sub-falsifiability is desirable, and if for considered falsifiers multiple methods used together facilitate CoMS above zero, a multi-method M&S approach is justifiable.

Interpreting Popper (2002), preference should be given to those theories which can be most severely tested, which in M&S context is related to higher universality and precision of models, which are prerequisite of testing these theories. In other words, if multiple methods have desirable unique characteristics in the study context they can be used, which in turn should improve the developed simulation model and study outcome. For instance, if CoMS is evaluated to critical it means that original method(s) was/were insufficient for the potential falsifiers considered. The added method has then a critical effect to enhance the approach toward a desirable level of falsifiability (sub-falsifiability).

3.2 Justification Principle 2

If a higher degree of sub-falsifiability is desirable, an approach with higher CoMS for considered potential falsifiers is more justifiable.

Ranking of methods against potential falsifiers should lead to an insight about which set of methods is more appropriate. For instance, for a given set of different configurations in relation to different methods considered, a configuration with a higher CoMS is more justifiable.

3.3 Justification Principle 3

If, for considered potential falsifiers, CoMS equals zero, a multi-method M&S approach is not justifiable for expansion.

If CoMS is estimated as none, there is no justification to utilize multiple methods based on gain of sub-falsifiability. A pseudo-triangulation of a concept using multiple methods (assuming high sub-falsifiability scores) is possible. This would mean that if, for given potential falsifiers, sub-falsifiability of each method used in total separation is the same then both methods have equivalent characteristics for a given purpose. Pseudo-triangulation between views created with method(s) at the same level of falsifiability for a given purpose may be conducted in cases where methods are the same and are adequate for the purpose. If the purpose of triangulation is to examine replicability of a concept, M&S methods or their combination used as separate instances should be able to realize the same concepts and possibly similar results for comparison but through the lenses of different M&S methods. Because the differences in methods could cause different results, the comparison of M&S methods would be a part of explaining the differences in produced theories. It should be pointed out that a single modeler could to some degree benefit from pseudo-triangulation, but engaging different modelers would facilitate more objective triangulation.

3.4 Justification Principle 4

If, for considered potential falsifiers, neither of the classes of potential falsifiers of hypothetically combined methods could include the other(s) as a partial subclass, the methods have non-comparable potential falsifiers and complementarity and triangulation are not justifiable.

In this case, methods cannot be used for comparison or expansion because they do not have relevant mental, numerical, or language domains of consideration.

4 DISCUSSION

The aspect of observation as conveyed by Popper (2002) in the context of the choice of M&S methods is more problematic. The purpose of knowing which method or combination of methods to use in addressing a research question would require testing empirically (developing simulation models) all possible configurations within the research context. The meta-analysis is clearly necessary in the context of M&S method selection for a multi-method M&S approach whether considered as scientific, philosophical, or somewhere in between, e.g., as proposed by Mingers (2001) by removing constraints related to established "paradigms" by separation of research methods from paradigms. This requires a higher-level analysis as compared to a level at which theories are described, for instance those theories that could be developed using M&S methods. The concept of commensurability of methods introduced earlier in this paper provided some insight into this concern. Popper (2002) admitted that the one method of rational discussion is "that of stating one's problem clearly and of examining its various proposed solutions critically" (p. xix). The analysis of M&S methods should follow this advice to avoid naïve falsification, e.g., in relation to method selection by examining several potential falsifiers.

Current research guidelines for a multi-method M&S approach are often method- or domain- (or both) specific (Chahal 2010, Glazner 2009, Swinerd and McNaught 2012, Borshchev 2013). This view can cause constrained, domain-based conceptualizations, and assumptions specific to a given set of methods. The guidelines should facilitate enhanced conceptualization by providing option for employing multi-method M&S approach, and consequently arrival at more desirable falsifiability level. This can be viewed as seemingly opposing goals: devising a robust, systemic approach, and better flexibility and creativity of modeling process. Both opposing aspects can be important within a multi-method study at different stages, facilitating better chances of insight into research questions and solution(s) to problem(s). In order to increase research objectivity and transparency transitions toward method formats introduced by Balaban, Hester, and Diallo (2014b), must seek justification as directed by proposed earlier principles. Potential falsifiers could highlight unique aspects of methods, explaining specific merits of multi-method M&S approach and possible configurations. Currently, criteria for method(s) selection are often used as a way to support the use of multiple methods (Axelrod 2004, Behdani 2012, Chahal 2010, Finnigan 2005, Helal 2008, Lane 2000, Lorenz and Jost 2006, Schieritz and Milling 2003). On the other hand, it could be argued that potential falsifiers could offer a more precise and tailored perspective to study point of view.

Because it would not be appropriate to use a single potential falsifier, even for the same set of methods considered different set of considered potential falsifiers could yield different CoMS results. This leads to a few necessary observations. The devised potential falsifiers could influence research objectivity and communicate its subjectivity. It is prohibitive and unjustified to use a set of methods based on a single potential falsifier. It is possible that a set of methods is used both for complementarity and triangulation reasons given that different potential falsifiers are considered. In cases where the decision to choose M&S methods during research design is blurred due to limited or subjective knowledge about systems and phenomena some approximated scoring would be required, and can be enhanced by triangulation of a competing configuration.

Triangulation and pseudo-triangulation could also be useful to confirm and evaluate correctness of estimated CoMS. The triangulation of internal methodological decisions related to evaluation of different M&S methods considered should be interpreted quite the opposite as compared to examining replicability of a concept. The different results between options should aid to choose a more suitable approach. Triangulation in this case when producing the same results can be seen as inconclusive because not any particular choice exhibits merit. On the other hand, different results point to a more suitable option inducing credibility. It can be noticed that this triangulation focuses on identification of underlying merits of different methods, which could be used for evaluation of estimated CoMS. Triangulation can be also influenced when methods are preselected (Balaban 2015). This means that the methods may be artificially imposed by the modelers or stakeholders, influencing the rest of the process. Method(s) could be preselected in order to lower variability of results by considering the same method(s) as the original M&S study. From the perspective of commensurability of simulation models, the use of different M&S methods can lead to more incommensurable simulation models. On the other hand, the question is if preselecting methods is a justifiable practice when considering how this can limit possible variability leading to less credible triangulation.

CONCLUSIONS

This paper proposed four theoretical principles for justification of the use of multi-method M&S approach. The principles were derived base on a theory of falsification and serve as a mechanism for reasoning about M&S methods choices in the context of desirable level of falsifiability. In this context, CoMS was proposed as a measure used to justify the use of multiple M&S methods, potentially allowing to improve ability to evaluate methodological quality of M&S research. Future work will examine proposed in this work principles using criteria for methods selections (as proxies for potential falsifiers), also discussing usefulness of the criteria. Next, it is necessary to develop a technique(s) that estimates CoMS. The ultimate goal is a general research guideline for conceptualization using a multi-method M&S approach.

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