

can be considered as plausible). In that sense, abduction can be interpreted as an inductive method *loosened* to come up with any set of plausible hypotheses or explanations; rather than concentrating on only one hypothesis as induction method does. From a “systems” perspective, deductive reasoning operates within a well defined “closed” system of “premises”, whereas inductive and abductive reasoning types go beyond the “premises” and therefore take place in an “open” system.

4. Syllogism in Modelling Process

The three types of reasoning - abduction, deduction, and induction – although discussed one by one separately, they are mostly operative collectively and supportively in every stage of an IE/OM modeling process, as will be discussed in this section. Their sequence and dominance level, however, might change from one stage to another in a modeling process, as it is shown in Table 2.

Reasoning Types in Conceptualization: Conceptualization stage entails both “managerial situation” – research issue or problem; and “conceptual model” – in fact a theory. “Managerial situation” is in essence finding or identifying a “surprising fact” or an “anomaly” that needs to be dealt with. In this context, a “surprising fact” could be a problem to be solved, launching a new product, developing a new technology, formulating competitive strategy, entering a new market, coming up with a new idea of any kind, or any issue that is not a matter of a routine course. This “surprising fact” or “managerial situation” is to be understood and explained in the best way possible. This is the kernel of abduction method. Therefore, “managerial situation” and abductive reasoning coexist and one without the other is incomplete. Finding or creating a best explanation for a “managerial situation” needs to be done in a logically consistent and transparent manner, a process that stipulates deductive reasoning. In other words, abductive method is to be supported by deduction while communicating “managerial situation” to others. In order to convince others even more, analogies and metaphors can be used as an application of inductive reasoning. In summary, abduction is sensemaking about the reality to define a “managerial situation” whereas deduction and induction are sensegiving to others about “managerial situation.”

The resultant of conceptualization is a “conceptual model.” We have already established that “conceptual model” is but a theory. In that theory, we need new concepts that are related to the “managerial situation.” These new concepts are to be conceived or invented by abductive reasoning. Constructing a set of relationships between the concepts is to be achieved by deductive reasoning; and finally the set of relationships between the concepts are to be justified by inductive reasoning.

In summary, for the conceptualization stage, the dominance order of reasoning types, as indicated in the last column of Table 2, is as follows: (1) abduction, (2) deduction, and (3) induction.

Reasoning Types in Model Building: The process of model building takes “conceptual model” and converts it into a “formal model” through suggesting/stating propositions between constructs, if the abstraction level is high; and formulating the hypotheses between variables if the abstraction level is low. Formulating hypotheses (in the forms of statistical or optimization models) are more frequent in the IE/OM field and mathematics is usually the instrument for this conversion. “Formal model” is expected to mimic as much as possible the “conceptual model.” As such, the consistency and verifiability of models become main concerns in this stage and these properties are secured primarily by deduction and induction, and then by abduction if new ideas are needed in model building methods.

Reasoning Types in Solution Obtaining: This stage is similar to the model building stage in that both have the same dominance order; that is, deduction, induction, and abduction. Solution obtaining stage requires the development and use of algorithms where deductive reasoning is unavoidable, simply because modeling language is mostly mathematics or mathematics-based devices. The solutions obtained from the formal model are to be justified in the sense that they are meaningful in empirical terms. This is where inductive reasoning is in demand. Regarding abduction, many new algorithms or techniques necessitate conceiving new theories and hypotheses. Conceiving new ideas and theories, as stated before, require abduction method.

Table 2: Reasoning Types in IE/OM Modeling Process

Modeling Stage	Connected Resultants	Dominance Order and/or Sequence of Reasoning Types
<i>Conceptualization - Reflecting Ontological Assumptions</i>	Managerial Situation and Conceptual Model	1. <i>Abductive</i> 2. <i>Deductive</i> 3. <i>Inductive</i>
<i>Model Building - Reflecting Epistemological Assumptions</i>	Formal Model corresponding to Conceptual Model	1. <i>Deductive</i> 2. <i>Inductive</i> 3. <i>Abductive</i>
<i>Solution Obtaining- Reflecting Methodological Assumptions</i>	Solution Methods and Techniques	1. <i>Deductive</i> 2. <i>Inductive</i> 3. <i>Abductive</i>
<i>Implementation - Reflecting Axiological Assumptions</i>	Decisions and Managerial Situation	1. <i>Inductive</i> 2. <i>Abductive</i> 3. <i>Deductive</i>

Reasoning Types in Implementation: The success of any implementation is very much dependent on the acceptance level of the model built and the solutions obtained from it. In this stage, it is necessary to inductively show that the model and solutions are empirically justifiable. Moreover, the actionable knowledge thus suggested/produced has the potential to deal with the “managerial situation.” Whatever the anomaly or surprising event implied by the “managerial situation,” the suggestion/solution obtained is the best or nearly the best response possible – requiring abduction. These two reasoning types are to be supported by deduction method for consistency and transparency in communicating the model and solutions to other stakeholders. Thus the dominance order of reasoning types suggests itself as induction, abduction, and deduction, as shown in Table 2.

5. Discussion

Given that modeling process is in essence an actionable knowledge or theory production process, then we can claim that the three reasoning types are to be used in such a manner that they support and complement one another. The integrating dynamics of syllogism in this sense is depicted in Figure 3.

It is appropriate to give some concrete examples where abduction is supported by deductive and inductive methods. Structural Equation Modeling (SEM), a multivariate statistical analysis technique, is a tool which starts with a set of data. So, the “case” is given and fixed. The objective is to come up with a structural model that explains the data in the best way possible. For this very purpose, researchers usually develop a measurement model first through explanatory factor analysis (EFA) – in the absence of theory about structural relationships between constructs or latent variables, and then validate them with confirmatory factor analysis (CFA). Once the measurement model passes the validity tests, then structural model is built to express the interrelationships between the constructs in a series of linear regression equations. From the perspective of syllogism, SEM is completely faithful to the data, which is the main feature of abduction, and seeks and tests theories – which are structures that link observable variables and unobservable, but useful latent constructs, that are consistent with the data. This abductive approach of SEM is however formally performed through a completely deductive reasoning. Therefore the domain of abductive reasoning is constrained by the basic methodological assumptions of SEM –which are

entirely provided by deductive reasoning; for instance, all the relationships between variables and constructs are linear and no feedback is allowed.

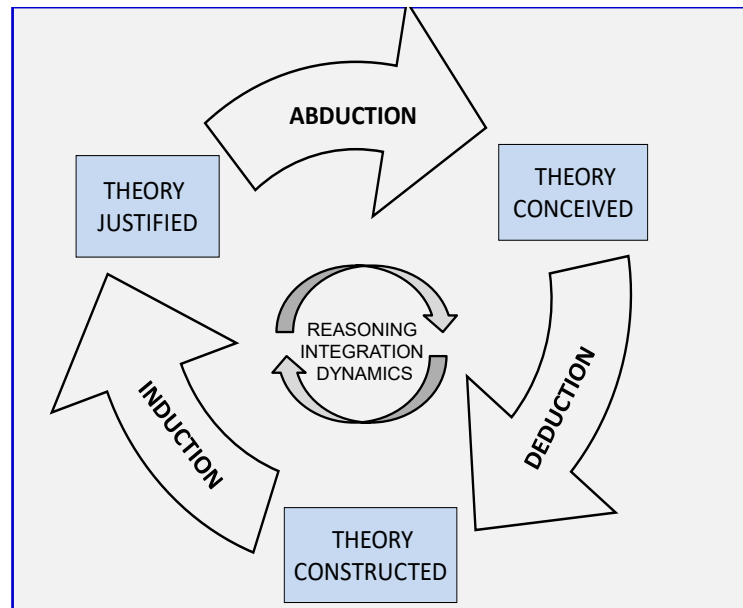


Figure 3: The Integrating Dynamics of Syllogism in Modeling Process

The dominance of deduction and induction, and especially that of deduction through the “mathematization” of IE/OM, in the “positivist/scientist” tradition/approach of IE/OM has been the main issue of considerable debate as to the validity and legitimacy of the models developed for the purpose of organizational interventions. This dominance of hard paradigm has later created what is called “crisis in IE/OM” to which British and European researchers were more responsive than their US counterparts (Kirby, 2007). Pursuing hard paradigm has produced models that were not only self-limiting because of their excessively complicated mathematics (Ackoff, 1973) but also counter-performing in organizations and thus diminishing their possible effectiveness in interventions. Admitting the gap between theory and practice, a group of IE/OM researchers, in UK and Europe as well as in USA, identified the main cause as the model builders’ lack of understanding the reality as perceived by model-users and problem owners. As a remedy, engaging all major actors in modeling process, especially in the stages of identifying and formulating problems, has become a necessity. For this purpose, several approaches and methods have been developed and used successfully in practice (Mingers, 1997, 2003). Among these are “problem structuring methods,” “soft systems methodology,” “multi-methodology,” “facilitated modeling,” and “cognitive mapping.” This is an important shift in IE/OM in terms reasoning types as well. Now, abduction is also becoming, although implicitly, a part of modeling process, in addition to deduction and induction.

One last point regarding paradigmatic assumptions of modeling process, the ontological assumptions gives prominence to *doing the right things* whereas epistemological and methodological assumptions to *doing the things right*. Axiological assumptions, on the other hand, aim at securing the paradigmatic assumptions well confirm to a set of acceptable ethical requirements.

6. Concluding Remarks

The importance and roles of the three types of reasoning in logic are discussed in connection with the stages of a modeling process in IE/OM field. Although it is not explicitly stated yet, there is tendency to move from the deductive and inductive dominance (hard IE/OM) to abductive dominance (soft IE/OM) as concentration intensifies

on engaging all major actors in modeling process. It is thought and hoped that IE/OM researchers will make use of abduction, deduction, and induction methods more explicitly in their future work. Particularly, the usefulness of abduction in generating new ideas in problem formulation and theory building will be recognized and new avenues will be opened for abductive reasoning in addition to those for deduction and induction.

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