Epistemic Contributions of Models: Conditions for Propositional Learning

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This article analyzes the epistemic contributions of models by distinguishing three roles that they might play: an evidential role, a revealing role and a stimulating role. By using an account of learning based on the philosophical understanding of propositional knowledge as true justified belief, the paper provides the conditions to be fulfilled by a model in order to play a determined role. A case study of an economic model of the labor market—the DMP model—illustrates the usefulness of these conditions in articulating debates over the epistemic contributions of a given model.

Introduction

Models are powerful tools that can make us learn. Few contemporary observers of science doubt that, and economists agree; the highest honours of their discipline go to the most influential model builders. Among a long list of modellers who are Nobel laureates, we count Peter A. Diamond, Dale T. Mortensen and Christopher A. Pissarides, who were awarded the prize in 2010 as a recognition of their work in developing a model of the labor market—the DMP model.[1]

While researchers agree that models make significant epistemic contributions in science, judging whether a specific model made us learn is no

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1. DMP stands for the initials of the three modellers.

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easy matter. The recent literature on models, though rich in insights, is not as helpful as one might hope in dealing with this issue. Much energy has been spent arguing that models *can* be highly useful and there are today lists of what they *can* do (e.g., Morgan and Knuuttila 2012, p. 73). Unfortunately, these lists give us little handle when it comes to analyzing claims about whether we have learned from a specific model and in what sense.

The main goal of this article is to help with such analysis. In particular, we highlight three epistemic roles that models can play in our learning about the world. In addition, we provide conditions that are sufficient for each role to be actually played by a given model. A secondary contribution of our paper is to connect more tightly the discussion on "learning from models" to general epistemology. We connect the two by using the traditional account of propositional knowledge to analyze how models can help us learn about the world. Our explicit epistemological perspective allows us to structure the relationship among our three epistemic roles and to articulate how learning from models fits into a more general picture of knowledge acquisition.[2]

The scope of our project must be properly delimited. We do not claim that the three roles identified are the only ones models might play. We are also not the first to try to supply conditions for learning from a model. For instance, the proposals by Alexandrova (2008), that models supply open formulae and Grüne-Yanoff (2009), that they falsify impossibility hypotheses, can be understood in terms of attempting to provide sufficient conditions. Yet, the present article goes beyond these contributions by identifying conditions for a number of epistemic roles and by articulating these conditions with the help of the traditional account of propositional knowledge.

Our general account of learning is presented in the next section. We then discuss our three epistemic roles. Finally, we present a case study of the DMP model, which is meant to illustrate how our conditions can help in structuring a fruitful debate over the epistemic contributions of a given model.

On Learning

To be able to characterize precisely potential epistemic contributions of models, we need to be clear on what we take learning to be. For the purpose of this paper, we propose to take learning to be the process of "coming to

2. By using an epistemological concept of learning, we are not suggesting that other perspectives—e.g., cognitive—are not fruitful or important.

know" (Audi 2011, p. 162), and to rely on the traditional account of knowledge as true justified belief. According to this account, which is about knowledge of propositions, an agent knows a proposition if and only if three conditions hold: (i) the proposition is true, (ii) the agent believes the proposition, and (iii) the agent has an appropriate justification for this belief.[3]

Propositional knowledge is only one type of knowledge, which excludes other types of knowledge such as knowledge-how (see Fantl 2012). This restricted focus of ours might be a significant omission when we think about models since it is very likely that models contribute to know-how besides contributing to know-that (i.e., propositional knowledge). For instance, through exercising with models, one might develop abilities to better react to various real world happenings much in the same way an aircraft pilot develops intuitions and reflexes in a flight simulator. Although we recognize that a significant amount of learning can be related to knowledge-how, we think that providing explicit conditions for learning in terms of propositional knowledge is already a significant contribution, to which we limit ourselves here.

The traditional account of knowledge as true justified belief (KATJB) is not without its faults. Since Edmund Gettier's famous article (Gettier 1963), it is largely granted that the three conditions stated above, though apparently necessary, are not fully sufficient for knowing a proposition. Once the general structure of Gettier's counterexamples is understood, it is easy to produce thought experiments in which a true justified belief can intuitively not count as knowledge (Zagzebski 1994). Although this implies that there could be cases that our account would regard as involving learning—acquiring knowledge—when in fact knowledge is not acquired, Gettier cases are scarce. By their very nature, Gettier cases can amount to only a small proportion of the elements in the set of all true justified beliefs (Hetherington 2011, p. 121). Since our goal is not to provide a definition of knowledge, an account that reliably, but fallibly, distinguishes between knowledge and non-knowledge is satisfactory.

There are good reasons to stick to KATJB in this article despite its drawback. First, the account focuses on what epistemologists still believe to be the concepts most tightly connected to propositional knowledge: truth, belief and justification. In fact, most of the recent accounts of propositional knowledge try to modify KATJB just enough to avoid Gettier

3. Some terms in this definition of knowledge—foremost "truth" and "justification"—could be given a variety of interpretations. We do not need to commit to specific interpretations for the purpose of this paper. For the major contending theories of truth and justification see entries in the *Stanford Encyclopedia of Philosophy* (e.g., Glanzberg 2013; Ichikawa and Steup 2012) and readers like Bernecker and Dretske (2000) and Bernecker and Pritchard (2011).

cases (Hetherington 2011; Ichikawa and Steup 2012). Second, KATJB is simpler than most other accounts and the best known. And third, none of the alternative accounts are free of problems; they all seem to fail to provide necessary and sufficient conditions for knowledge. There is simply no account that perfectly distinguishes knowing from not knowing.

What is clear, however, is that knowing is a state of an agent: at a certain point in time, an agent knows or does not know a proposition. By contrast, learning is a process of passing from a state of not knowing a proposition to the state of knowing it—it is coming to know. Thus, we characterise a process as learning if an agent starts the process lacking belief or justification (or both) in a true proposition, and ends it with both belief and justification in the proposition.[4] Before turning to models, we want to discuss the possible instances of learning implicit in the previous statement.

Learning can involve the process of coming to believe a true proposition. We want to distinguish between two possible ways in which this process of belief generation occurs. First, the agent can change her mind—change her doxastic attitude—with respect to this proposition. In this case, the agent starts the process either disbelieving the proposition or withholding judgment with respect to it and finishes the process believing it.[5] Second, the agent might start the process without even having a doxastic attitude for the proposition. Indeed, an agent holds, at any point in time, doxastic attitudes for only a tiny fraction of all the possible propositions she could envisage. In the 18th century, no one had a doxastic attitude for the value of Planck's constant. The process of coming to believe a true proposition can thus involve forming a doxastic attitude rather than simply changing it.

In addition to, or instead of, coming to believe, learning can occur through the process of coming to be *justified* to believe a proposition. The concept of justification relies on the distinction between adequate and inadequate evidence: an agent comes to be justified to hold a certain doxastic attitude if and only if her evidence for this attitude crosses the

4. In our account, the process of learning ends with knowledge. Some might want to work with a more permissive account for which learning is "coming *closer* to knowing" instead of "coming to know." The concept of "closeness" on which this alternative account relies is however difficult to pin down. It leads to difficult questions: Are we learning if we come to be justified in believing a false proposition? What if we come to believe a true proposition for entirely crazy reasons? Though we do not try to develop such a weaker account in this article, it might be possible to do so successfully; we therefore present our account as supplying only jointly sufficient (but perhaps not jointly necessary) conditions for learning.

5. Here we conceptualise doxastic attitudes in a trichotomous framework: disbelief, withhold judgment and belief, but it could also be rephrased in terms of, say, degree of belief.

threshold for adequacy. Evidence for a proposition suggests that the proposition is true; if the evidence is adequate, truth is indicated reliably. But even adequate evidence is fallible; truth and justification should not be conflated.

It is helpful to think about epistemic justification in terms of a network of doxastic attitudes for propositions connected to each other. Propositions can stand in an evidential relation to each other—believing one proposition warrants, to some degree, believing another. Since Paula believes that "the clock indicates 14.00 local time," she feels confident that "it is not night." If we locate the doxastic attitude for the proposition "it is not night" at the center of our network, Paula's belief that "the clock indicates 14.00" will be connected to this central node, together with many other doxastic attitudes.

The set of doxastic attitudes having an evidential relation with the doxastic attitude at the center of the network constitutes the evidence for this attitude. This evidence will be adequate or inadequate depending on properties of the network, such as its evidential density. This property summarizes the number of doxastic attitudes connected to the central attitude. The density of Paula's network centred at the belief in the proposition "it is not night" would be higher if, on top of believing "the clock indicates 14.00 local time," she also had a doxastic attitude for "the sun is shining through the window."

To sum up, we take learning to be about coming to hold a justified belief for a true proposition. Learning means that, at the start of the process, the agent does not *know* the proposition. Depending on what the agent is missing—belief or justification—learning involves either coming to believe or coming to be justified in believing (or both). In any case, the process ends with the three conditions for knowledge being met: truth, belief and justification. In the rest of this paper, this account will be used to answer the following question: How can models make us learn?

Learning with Models

Something that can be easily granted for most models is that by constructing and manipulating a model, an agent learns propositions *about* the model that she works with. We call these model propositions. Morgan (2012) refers to this learning as "enquiring *into* the model."

Two conditions must hold for it to be the case that an agent has learned *with* the model *about* this same model. First, the agent must be in the proper end state: there must be some true model proposition that the agent justifiably believes. In other words, the agent must, at the end point, *know* this proposition. Second, the agent's knowledge must have been acquired thanks to the modelling exercise. In particular, there are two relevant counterfactual dependencies: either the agent would not have *believed* the

proposition had it not been for the activity of generating the model, or she would not have been *justified* in believing the proposition (or both).

A model must thus make the agent believe the proposition, or make the agent be justified in believing the proposition, or both. How does a model make an agent believe a proposition? Modelling arguably generates beliefs in the two ways discussed in the previous section. Toying with a model makes the agent *form* doxastic attitudes for many model propositions that were not even on her radar before. That is, prior to the modelling exercise, the agent plausibly possessed doxastic attitudes just for a few model propositions—based on intuitions or theoretical considerations. Likewise, modelling might also lead the agent to revise previously-held doxastic attitudes with respect to some model propositions.

Regarding justification, the manipulation of a model typically provides justification for its model propositions. For instance, the fact that Arrow and Debreu (1954) derived the existence of an equilibrium in their general equilibrium model looks like adequate evidence for their belief that "an equilibrium exists in this model." It is also plausible to say that they did not have adequate evidence for their belief in this proposition prior to their derivation since the effort put in the derivation would make little sense otherwise. Note that this derivation and the belief that Arrow and Debreu are competent modellers are solid grounds for observers like us to grant one aspect of the end-state condition: this model proposition must be true. In short, in cases like the general equilibrium model of Arrow and Debreu, it seems implausible to deny that a model contributes to learning about itself in that agents come to believe and come to be justified in believing true propositions about it.

Granting that a model makes us learn about itself is obviously not granting much. Now we turn to how the agent's learning about a model can be a stepping-stone to learn about other target systems, especially phenomena in the real world.

Evidential Role: The Model Contributing to Justification

We start with what is perhaps the most contentious—and most discussed—potential epistemic contribution of models. Roughly, the idea of the evidential role is that *model* propositions, by contributing to justify *real-world* propositions, can contribute to learning about the world.

To begin, let us take the following real-world proposition: "Low employment protection is a cause of the low unemployment rate in the USA." At a certain point in time, an agent might lack justification—might have inadequate evidence—to believe this proposition and consequently develop strategies to increase the strength of her evidential network. The agent might, for example, investigate whether countries with more employment

protection typically have higher unemployment rates. By doing similar empirical research, she will increase the chance of being justified in holding her doxastic attitude for the initial proposition.

The question at issue when it comes to discussing the plausibility of an evidential role for models is whether model propositions can have the same function of strengthening one's evidential network for a real-world proposition. There are three conditions that must hold jointly for a model to play an evidential role. First, an end-state condition: there is a true real-world proposition p that the agent justifiably believes. Second, there is at least one model proposition q that is part of the agent's evidential network for p. Finally, if the agent did not have the doxastic attitude she has for q, she would not be justified in believing p. In other words, at least one model proposition makes a difference to knowledge: given the context, the doxastic attitude for model proposition q is necessary for justification.[6] This condition is meant to rule out situations in which the evidence is already adequate to justify the belief in p. In such situations, even if it were granted that a model proposition is part of the evidence for p—the second condition—there would not be an epistemic contribution, since the model proposition would be redundant for justification.

Whether and how often the second condition holds for economic models is the most contentious issue in the discussion of the evidential role in the literature. An influential view is that some propositions known to be true of the model are evidence for real-world propositions if, and only if, the model appropriately isolates the key features of the real-world system (e.g., Cartwright 1989; Mäki 2009). This view, however, leads some scholars to a skeptical conclusion (e.g. Reiss 2007; Alexandrova 2008): it seems that many specific assumptions are built in economic models that are doing more than cleanly isolating the key features.

Nevertheless, it can be argued that there are ways to avoid the conclusion that propositions about economic models are never part of the evidential network for real-world propositions. To start with, a model can indicate the falsity of particular types of real-world hypotheses—e.g., claims that something can never be the case—even though the model does not cleanly isolate key features of the real-world (Grüne-Yanoff 2009).

6. In contrast to the counterfactual dependence involved in learning about a model (see above) and to most of the ones discussed for the other roles below, the counterfactual dependence here is not causal, but rather logical or analytical (Kim 1973, p. 570). At the end state, the doxastic attitude for the model proposition is necessary for the evidence to believe p to pass the threshold for adequacy. When counterfactual dependence is causal, assessing it requires going back in the causal process resulting in knowledge to judge whether this process (and its end state) have been causally dependent on the model.

More generally, asking for a clean isolation of the target's key features appears too severe when we think of models as experiments in analogy to the experiments that we perform on one part of the world in order to learn about another part of it. For instance, we routinely test drugs on mice to assess their potential toxicity for humans. We run these experiments because we think that their results are evidentially relevant to our doxastic attitudes for claims about drug toxicity for humans. This source of evidence is far from perfectly reliable—a lethal drug for mice might be beneficial for humans and vice versa—which comes from the fact that mice do not share all the key features of a human organism. But it can hardly be denied that propositions about these experiments are often part of the evidential network of propositions about humans. The same might hold for models as credible worlds (Sugden 2000). Model economies are unlike real economies in many respects, much like mice are unlike humans. But the similarities shared by the two economies might be enough for model propositions to be counted as part of the evidence for real-world propositions.

We will not provide here a general, philosophical account of what it is for a model to be similar to a real economy, similar in the right way such that model propositions can become part of the evidential network for real-world propositions. Yet, the conditions provided in this subsection can help in structuring an argument to the effect that a specific model played, or not, an evidential role. This usefulness of our framework is illustrated below in our case study of the DMP model. Our illustration will also show, however, that these arguments are typically hard to uphold.

Revealing Role: The Model as Hypothesis Generator

We now turn to a potential epistemic contribution of models that is less discussed and sometimes simply referred to as a heuristic contribution. As we said above, one arguably learns about the properties of the model by constructing and manipulating it. In consequence, one comes to have justified beliefs in a host of true model propositions. One way by which this initial process can contribute to real-world learning is when some proposition about the model is transposed as a proposition about the world—that is, as a hypothesis about a target system of interest—and that the agent, in the end, comes to know this proposition. We would say in such a situation that the agent comes to form a doxastic attitude for the real-world hypothesis because of the model.

There are also three conditions to be met by a model to play this role. First, the end state condition: real-world proposition p is true and the agent justifiably believes it. The second condition is that there must be a conceptual connection between the model proposition q and p. More specifically, propositions q and p predicate the same, or sufficiently similar,

properties to their respective systems of interest. For instance, *q* could say that employment protection is a positive cause of the unemployment rate for model *M*, and *p* could say that the USA is such that employment protection and the unemployment rate are similarly causally related. We do not want to be overly restrictive on the conceptual connection required since some amount of interpretation is always necessary in order to take a property in a model to be sufficiently similar to a real-world property. It should however be clear that not any interpretation will do—e.g., propositions true of Bohr's model of the atom cannot legitimately be interpreted as sufficiently close to hypotheses about whether Columbia will have peace in the near future.

The final condition states a specific counterfactual dependence: if the agent had not known *q,* she would not have formed a doxastic attitude for *p*. In other words, if the agent had already an epistemic attitude with respect to the real-world hypothesis or if this real-world hypothesis was bound to be considered because of other developments—a case of overdetermination—then the model would not be making an epistemic contribution.

Is there a link between the conceptual exploration discussed in many commentaries on models (e.g., Hausman 1992, p. 79; Nersessian 2008; Morgan 2012, pp. 270–72, 368–72) and this revealing role? It is to be expected that many of the hypotheses revealed by a model come up through the creation, exploration and clarification of some concepts through modelling.[7] After all, models are widely recognized for their role in creating, exploring and clarifying concepts. For instance, the advent of game theory brought many concepts to the forefront, one example being the distinction between incomplete and imperfect information or, more famously, a situation having the structure of a prisoner's dilemma. However, there is no necessity in the connection between conceptual exploration and the revealing role; it might well be that some hypotheses are revealed by further manipulation of a model using well-established categories.

Stimulating Role: The Model as Stimulus for Empirical Research

Models can suggest more than hypotheses; they can also suggest ways to increase the density of the evidential network for real-world hypotheses that the agent cares about. In other words, models can stimulate empirical

7. As we stated above, here we restrict ourselves to propositional learning from models and say only little about other potential types of learning from models. We already noted the favourable prospects of an account also looking at procedural learning (i.e., resulting in know-how). A full epistemological account will also include conceptual learning—the introduction of vocabulary, see Audi (2011, p. 162–163).

research. This possibility forms the core of the last potential epistemic role we want to emphasize.

Part of the purpose of doing empirical research is to come to form doxastic attitudes for more real-world propositions (e.g., experimental results) that are evidentially related to propositions that the agent cares about. Models can help increase the density of one's evidential network because the propositions to investigate in order to justify one's doxastic attitude for a hypothesis are not always evident. By toying with the model, researchers can come to realize that some empirical research would be relevant to conduct. The role of the model here is thus to *stimulate* pursuing novel empirical research.

Again, three conditions need to be satisfied by a model to fulfil this role. First, the end state condition: a real-world proposition p is true and the agent justifiably believes it. Second, there is another real-world proposition r for which the agent has a doxastic attitude, but the research that generated the agent's doxastic attitude for r would not have been pursued had it not been for the modelling exercise. In other words, the model has a causal influence on the generation of a doxastic attitude for r and it has this influence through stimulating research.

Finally, a third condition requires that the doxastic attitude for r is a non-redundant element of the evidential network for p: if it were not for the doxastic attitude for r, the agent would not be justified in believing p. The evidential network would not reach the threshold for adequacy if the agent did not entertain this attitude.

Like for the revealing role, the stimulating role is tightly linked to conceptual exploration, although we should not see conceptual novelty as being necessary to the revealing role. The link is tight because what makes modelling a particularly effective activity at coming up with new ways to investigate target systems is, perhaps, that modelling makes us conceptualize the world differently.

An Illustration with the DMP Model

The previous section discussed potential epistemic roles of models. Now we turn to looking at different claims made in the literature regarding the epistemic contributions of the DMP model. The main goal of this section is to illustrate that our epistemic roles neatly dissect various assertions about this model and that they indicate what is required for these assertions to be true. In addition, we will argue that the DMP model actually played specific epistemic roles while recognizing that our arguments, being based on empirical propositions, are disputable.

The origins of the DMP model go back to the end of the 1960s when many researchers were looking for new "microeconomic foundations of

employment and inflation theory" (the title of Phelps et al. 1970). The core idea embedded in this model is that the labor market is a matching system with search frictions. There are frictions because, on the supply side, job seekers are not instantaneously informed about all the job offers and their associated advantages and, on the demand side, potential employers have no direct access to all job seekers and their wage expectations. A match between a job seeker and an employer takes time since they must find each other. When a match occurs, each side has some bargaining power since it would be costly for the other side to break the match and go back to search mode.[8]

The best way to see the peculiarity of the DMP model is to contrast it to the main model of the labor market predating it. This earlier model—still taught in introductory labor economics—depicts the labor market as a standard neoclassical market with price-taking demand (i.e., firms) and supply (i.e., potential workers). The two sides of the market are summarized—as usual—in a downward-sloping demand and an upward-sloping supply. The quantity of labor actually used and the associated wage rate (if nothing interferes) is taken to be the intersection of these two curves—the competitive equilibrium. In this model, unemployment is interpreted as being caused by factors forcing the wage rate to be higher than the equilibrium wage rate, thus implying an over-supply of labor at the given wage. In contrast with the DMP model, there is no idea of time necessary for a match to occur, and there is no idea of wage bargaining between the two sides of a match.

Evidential Role

Many economists interpret the DMP model as providing evidence for real-world claims. For example, the press release accompanying the announcement of the 2010 Prize in Economic Sciences stated that:

> The Laureates' models help us understand the ways in which unemployment, job vacancies, and wages are affected by regulation and economic policy. [...] One conclusion is that more generous unemployment benefits give rise to higher unemployment[...] (Nobelprize.org, 2010b)

This claim can plausibly be interpreted as asserting that the DMP model played an evidential role with respect to the real-world proposition: "In

8. For a book-length exposition of the model, see Pissarides (2000); for shorter presentations, see Cahuc and Zylberberg (2004, pp. 517–536) and Nobelprize.org (2010a, pp. 12–20).

real economies, more generous unemployment benefits give rise to higher unemployment" (henceforth '*p*').

Did the DMP model play an evidential role with respect to *p*? In other words, are the conditions presented in the previous section met? Regarding the end-state condition, there are reasons to grant that it is met: first, the vast majority of economists *believe* the real-world proposition *p*; second, a rich literature using different methods and data seems to provide adequate evidence to justify this belief (for surveys, see Fredriksson and Holmlund 2006; Boeri and van Ours 2008, ch. 11); third, since justification reliably—yet fallibly—indicates the truth value of a proposition, *p* is likely to be true.

There are also some reasons to grant that at least one proposition about the DMP model is part of the evidential network for *p* (the second condition of the evidential role). In this case, the most plausible proposition *q* is "In the DMP model, more generous unemployment benefits give rise to higher unemployment," which is indeed a known property of the model. Among economists, the argument for the view that *q* is part of the evidential network for believing *p* includes claims about the realisticness of the model[9] and, most importantly, about the fact that many results of the DMP model concord with results independently obtained with empirical methods (i.e., a claim about the degree of output validation of the model). Since the model seems to track the world so well on many aspects, we can, the argument goes, take truths about it as belonging to the evidential network for real-world propositions like *p*. Note that this argument does not imply the dubious claim that one would be justified in believing *p* on the sole ground of knowing *q*. In the present case, *q* is one element among many more propositions in the evidential network for *p*. Other important propositions are concordant results from statistical analyses of various types that do not rely on the DMP model (see Claveau 2011).

Finally, there is a compelling reason for why the justification of *p* counterfactually depends on knowing *q* (the last condition). This model proposition is a novel model result in the sense that, perhaps surprisingly, the model of the previous generation (the standard supply and demand model, see above) did not have the conceptual resources to produce a relationship between unemployment benefits and unemployment.[10] Since the DMP

9. For instance, Pissarides says in his Nobel lecture: "To me, search theory was appealing as a foundation for a theory of unemployment because it appeared realistic." (Nobelprize.org, 2010c) See also Blanchard 2007, pp. 413–14.

10. The closest proposition to *q* one could get in this earlier model is: "In this model, higher unemployment benefits decrease employment." Indeed, generous unemployment benefits were modelled as decreasing the labour supplied at any wage; thus decreasing equilibrium employment, not increasing unemployment. See Boeri and van Ours 2008, pp. 230–34.

model has these conceptual resources, it would be pretty devastating if there was no way to produce a positive relationship between benefits and unemployment in the various versions of the model. This incapacity could indicate that the statistical results are all artifacts. By contrast, knowing *q* helps support the belief that the empirical results pointing to a causal link from benefits to unemployment are not all spurious.

Although we side with most economists here in believing that the DMP model played an evidential role with respect to this specific *p*, we readily note that there is room for objections. It could be argued that the end-state condition is not met because, for instance, the evidential network for *p* is more sparse and incongruent than we are ready to admit (cf. Howell 2005). One might also wonder why *q* should be taken as even a mildly reliable guide to the truth-value of *p* given that some elements and results of the DMP model are quite unlike the world.[11] Finally, the ones reacting against the centrality of the modelling culture in economics (e.g., Lawson 1997) might reply that *q* is redundant, that we have no need of a model proposition in the evidential network for *p*. We think that these objections can be satisfactorily answered, but these answers would require developments unnecessary for the purpose of this paper.

Revealing Role

The DMP model has been praised for being a great platform to think about the labor market. For instance, Olivier Blanchard (2006, p. 26), current chief economist of the International Monetary Fund, wrote that, compared to the earlier model, the DMP model is a "richer framework to think about unemployment, a framework based on flows, matching and bargaining." Blanchard is here emphasizing the possibility of extensive conceptual exploration through the DMP model. The concepts brought to the forefront by this model include a clear distinction between flows and stocks of workers, matching efficiency, search intensity, and wage bargaining. One way by which this conceptual exploration can result in propositional learning about the world is the revealing role.

There are many new questions that can be investigated inside the DMP model but could not in the earlier model: what is the relationship between the stock of unemployed people and the flows in and out of unemployment? What determines the speed at which potential workers are matched to firms? More specifically, what determines the search intensity of unemployed

11. For instance, even proponents of the model take its depiction of bargaining as being "a very poor description of reality" (Blanchard 2007, p. 414) and recognize that it does not manage to replicate even something as central as the cyclical fluctuations in unemployment (Nobelprize.org 2010a, p. 23; Shimer 2005).

persons? What matters to the bargaining process between firms and their potential employees? For the DMP model to play a revealing role, a necessary condition is that some answers to these or similar questions with respect to the model be transposed as hypotheses about the real world.

Take, for example, what economists call the entitlement effect of unemployment benefits (Mortensen 1977; Boeri and van Ours, 2008, sec. 11.2.2). While discussing the evidential role, we said that unemployment benefits are believed by most economists to increase unemployment, but Mortensen realised that, in one version of his model, one group of job seekers had shorter spells of unemployment when unemployment benefits were higher.[12] This group is the one that is not covered by the unemployment benefit system, but can expect to be covered during its next unemployment spell. Since getting a job also involves a better future as unemployed, this group has incentives to find a job faster.

Once this entitlement effect is shown to exist in the model, economists might entertain a related hypothesis about the world: "Increasing unemployment benefits in a real country will reduce the length of unemployment spells for at least some uncovered job seekers" (henceforth '*p*'). The DMP model seems to have played a revealing role with respect to learning *p*.

The second condition for the revealing role—the conceptual connection—should be easy to grant in this case. Although the DMP model is highly idealized, we can locate a group of agents in it corresponding to the real individuals that are both jobless and unaided by the unemployment insurance system. We can also easily associate a property of the model group to the lengths of unemployment spells in our real group. The conceptual link between the entitlement effect in the DMP model and *p* is thus hard to question.

Is the end-state condition fulfilled? Many economists—especially among the ones specialising in labor economics—*believe p*, which claims only the existence of entitlement effects among some job seekers. Although few empirical studies have tested the real-world existence of entitlement effects, the existing results seem sufficient to justify *p*.[13] And *p*, given this evidence and given the weak requirement for the claim, is likely to be *true*.

Can we also grant the last condition that it would not have occurred to economists to believe *p* had it not been for the development of the DMP model? To the best of our knowledge, *p* was not entertained prior to the

12. It is because the entitlement effect is dominated by other effects at the aggregate level that most economists believe that, for a whole economy, unemployment benefits increase unemployment.

13. For instance, Bennmarker et al. (2007) find evidence of an entitlement effect for men, but not for women.

modelling work of Mortensen (1977) and there is no parallel literature today talking about something like *p* without being aware of Mortensen's work. Though we cannot definitively rule out that *p* was bound to be entertained soon enough independently of the development of the DMP model, the available evidence points toward the fulfilment of this last condition too.

Stimulating Role

A contribution of the DMP model might have been to stimulate empirical research in epistemically valuable directions. The Economic Sciences Prize Committee claims that the development of the DMP model had this effect. According to this committee, the contribution was twofold. First, the model stimulated data collection:

> The early microeconomic models of job search initiated new data collection efforts focusing on individual labour market transitions, in particular transitions from unemployment to employment. (Nobelprize.org 2010a, p. 20)

By changing the modelling focus from stocks to flows, the development of the DMP model stimulated researchers to request (or, less frequently, actually gather themselves) reliable data on flows.

Second, the DMP model gave impetus, according to the Prize Committee, to the use and refinement of some empirical methods, most importantly duration analysis[14]:

> The methodological literature on econometric duration analysis has expanded substantially over the past couple of decades, a development that is to a large extent driven by the growth and impact of microeconomic search theory. (Nobelprize.org 2010a, p. 23)

Can we thus say that the DMP model played a stimulating role? Take, for instance, the following proposition *p*: "the [U.S.] private-sector (gross) job creation rate began declining well before the 2001 recession and continued to slide until the middle of 2003." (Davis et al. 2006, p. 24) It can hardly be doubted that the first and the last conditions hold with respect to *p*.

To start with, Davis et al. believe *p*. They base this belief on the analysis of two data sources: the Job Openings and Labour Turnover Survey (JOLTS; see Clark and Hyson 2001) and the Business Employment Dynamics (BED) data (Pivetz et al. 2001). The authors put forward two propositions in their

14. Duration analysis as applied to labor markets empirically studies the length of unemployment spells and the factors explaining it.

analysis. First, "[f]igures 2 and 3 [plotting BED data] show a long downward slide in job creation rates before, during and well after the 2001 recession" (Pivetz et al 2001, 12). Second, "[t]he hires rate [from the JOLTS] declines from 3.8 per cent of employment in December 2000 to 3.0 per cent in April 2003" (Pivetz et al. 2001, 13). We denote these two propositions q_1 and q_2. Note that q_1 and q_2 are about patterns in data, while p is directly about the United States. Propositions q_1 and q_2 constitute the main evidential ground for p. It is thus hard to deny that believing them is a necessary condition for being justified to believe p. Furthermore, q_1 and q_2 seem to be sufficient to justify believing p. In particular, the fact that both data sources produce a similar pattern makes it unlikely that this pattern is driven by an artifact in the data. Finally, since believing p seems to be justified, we should be tempted to grant the truth of p. In short, it is highly plausible to affirm that Davis et al. know p (first condition) and that they do so thanks to q_1 and q_2 (last condition).

For the DMP model to have played a stimulating role with respect to p, the second condition must also hold: if the model had not been developed, would economists be in a position to believe evidential propositions like q_1 and q_2? The opinion relayed by the Prize Committee (see above) is that the model is responsible for the collection of new data like the JOLTS and BED data, and thus, ultimately, for the beliefs in q_1 and q_2. We have no substantial reason to reject this opinion—the data collection and the active development of the methods started after the initial work on the DMP model and the scholars involved in all these developments had significant interactions during the period.

That the DMP model played a stimulating role with respect to learning p might not be granting much. This proposition is descriptive and it pertains to a single country for a specific period of time. But the stimulating role of the DMP model might become impressive if we can be convinced that many other propositions were learned through this role. These propositions will not be necessarily local and descriptive; they could be descriptive generalizations justified by pooling national surveys together or they could be causal propositions justified by combining duration analysis and natural experiments. We do not have space to explicitly argue for these epistemic contributions of the DMP model. We simply note that, if we grant these contributions, the DMP model would have stimulated a great deal of learning about real economies.

The same point holds for the evidential and revealing roles. By focusing on specific propositions, we could have given the impression that these contributions amount to little. But the overall epistemic contribution of the DMP model would be impressive if convincing arguments using a wide array of important real-world propositions could be constructed.

Conclusions

A model can make us learn in a variety of ways. This paper discussed several ways by which propositional learning can occur with models. Manipulating the model can obviously make us learn truths about the model itself. But, more importantly, a model might also contribute in different ways to make us learn about the world. We discussed three such ways. First, truths about the model might be part of the evidence justifying one's belief in a true real-world proposition—the evidential role. Second, truths about the model might reveal real-world hypotheses that turn out to be true and justifiable—the revealing role. Third, the model might stimulate researchers to undertake new empirical research, the result of which comes to justify beliefs in some true real-world propositions—the stimulating role. For each of these roles, we provided and discussed a list of conditions. We then used this framework to analyze the praises given to the DMP model.

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