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MODELS IN ECONOMICS: FABLES, FICTIONS, AND STORIES

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"We essentially play with toys called models"
(Rubinstein 2006: 865).

ABSTRACT

Mathematical modelling is the dominant linguistic instrument in contemporary economics, and the canon with which to assess the scientific character of theories; but it has forever lost the pretence of truth. In current research practice in the discipline, mathematical models are conceived as born from the economist's imagination, and flexibly adaptable for reasons of interpretation or technical convenience. A model is the formalization of some fictional world. The criteria used to associate models with the explanation of economic events are loose and controversial. No shared, structured canon exists to validate or reject the significance of a model, and even the criterion of empirical validation has lost appeal. New currents in methodology reflect the practices in advanced research, suggesting that models in economic theory should be conceived as fables, fictions, or thought experiments on fictional cases. Academic communities validate models according to their presumed technical novelty, or because of fashion, ideology, and power. Sophistication in mathematical language is the primary canon conventionally adopted to validate models as acceptable within the mainstream. The paper questions the paradoxical coexistence in economics of the ambitious pretensions to hard science, and the ideas on mathematical models as fictional narratives about economic Wonderlands, which dominate in research practice and are reflected in studies on methodology.

Keywords: Mathematical Models, Fables Stories, Scientific Explanation.
JEL Codes: A11, A12, B41.

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1. Mathematical Language and the Quest for Scientific Truth

In 1844, writing on commercial crises, J.S. Mill attributed a myopic vision to traders in improvident speculations; he suggested that young persons to be employed in trade should be trained to understand better the fundamentals in the trend of prices [Mill 1967 (1844); Forget 1990]. His approach was both elitist and enlightened; the social philosopher does not share the myopic vision of the merchant in the understanding of economic life. In the invisible hand passage, Smith had expressed a similar judgement on the narrowly focused mind of the common trader, against the pretence of businessmen to express sound judgements on the welfare of society. In the 19th century, the scholars who built the mathematization of economics aimed at conquering scientific truth. They conceived the abstractions that mathematical modelling imposes in economic theory as the quest for ideal schemata of market phenomena which abstract from frictions. Mathematical language is the instrument of rigorous argument to uncover the inner laws of markets. Cournot, Walras, Jevons or Pareto, to cite the outstanding pioneers of mathematical modelling in economics, pursued the quest for scientific truth.

Cournot stated that the abstract idea of value in exchange in the mathematical theory of wealth should not be too far from "the actual objects" to which it should be applied; it should not become an "idle speculation" [Cournot 1971 (1838): 17]. He excluded utility from mathematical reasoning because he saw the idea as not amenable to scientific definition [Cournot 1971 (1838): 10]. In his *Recherches*, as in later works, he held that the idea of wealth can be studied as a mathematical object because contemporary societies are moving towards increasing rationalization in exchange: real markets move towards the reduction of frictions by progressively adopting rational evaluation and measurement [Cournot 1971 (1838): 10]. Walras, who argued that mathematical reasoning is the "rational method", not empiricism,[1] adopted the scientific procedure to start from the real types (*types réels*) of phenomena; these should be schematized into the ideal types (*types idéaux*), that is, conceptual structures rigorously defined on which to prove theorems, as with the ideal definitions of geometry. The concepts in mathematical economics are ideal skeletons of market phenomena, inspired by and abstracted from the types of market phenomena observed in reality. Mathematical language applied to the ideal types makes it possible to revert to experience to apply the theoretical conclusions reached. According to Walras's normative approach, pure economics deals with ideal exchanges

[1] "La méthode mathématique n'est pas la méthode *experimentale*, c'est la méthode *rationelle*". [Walras 1926 (1900): 29].

in perfectly competitive markets, which are normative standards towards which to approximate market realities because they respond to the criterion of commutative justice. Pure science conceives the perfect normative frame to regulate markets.

Throughout his life, Pareto was torn between the commitment to pure science in mathematical language and the search for the comprehensive understanding of social life that only the synthesis reached in sociology could offer [Pareto 1980 (1899): 170]. In his first treatise, he declared that his aim was "(…) to offer an outline of economic science considered as a natural science and founded solely on facts." [Pareto 1964 (1896-1897), I: III]. He defended the principle of successive approximations, pursuing the search to approach empirical evidence by proceeding from pure and applied economics to sociology to capture the complexities of social life. In pure economics he sketched the fictional character of the *homo oeconomicus* as a first step in theoretical research, but he aimed at going beyond it, venturing into applied economics and sociology [Pareto 1980 (1899): 170; Pareto 1982 (1918): 636]. Marshall took care to clarify the connections between mathematical modelling and economic reality; his cautious attitude towards mathematization is well known, although whether it changed over the years is controversial.[2] In a well-known letter, he wrote:

> The fact is I am the dull mean man, who holds Economics to be an organic whole, & has as little respect for pure theory (otherwise than as a branch of mathematics or the science of numbers), as for that crude collection & interpretation of facts without the aid of high analysis which sometimes claims to be a part of economic history. [Letter to W.A.S. Hewins, the 12th of October 1899 quoted in Coase 1993 (1975): 413].

Fisher, another pioneer of mathematical economics, wrote a book to explain how common people, and even the majority of businessmen, are victims of the money illusion in times of monetary instability (Fisher 1928). After failing to anticipate the collapse of stock prices in October 1929, he sought to rebuild the theory of fluctuations to account for the severity of major recessions. In *Booms and Depressions*, testing theories to fit the facts, he studied the early evolution of the depression in the US economy (Fisher 1932). He separated the "tendencies", i.e. the dynamic forces that theoretical analysis isolated by abstract reasoning on fluctuations, from the explanation of each episode in historical reconstruction (Fisher 1933: 338).

All these scholars, on different methodological premises, trusted the direct relevance of theory to understanding the real world of markets. In

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[2] See Letter to Edgeworth, 28 August 1902 in Pigou 1925: 437.

their quest for scientific truth, they shared the idea that economists are learned scholars who reach more enlightened intelligence in assessing the overall picture of the economy than do traders in their ordinary business. In designing the policies to be undertaken, they did not refrain from taking full responsibility for the consequences that they derived from their theoretical analyses of market economies. In contemporary mathematical economics, the quest for scientific truth is dead. We may or may not like this crude fact, but a crude fact it is. No scholar aims at discovering the laws of phenomena, as the pioneers did in the 19th or early 20th centuries, with their shared endeavour to place mathematical economics on the same scientific footing as physics. It was a major change with wide cultural roots.[3] On the evidence of the change, J. Reiss proposed "the explanation paradox", and he argued that no solution is as yet available (Reiss 2012).

(1) Economic models are false.
(2) Economic models are nevertheless explanatory.
(3) Only true accounts can explain. (Reiss 2012: 49).

In current research practice, economic theorists conceive models as conceptual tools born from their imaginations, and flexibly moulded for analytical reasons, or purposes of interpretation. Families of models are explored, or abandoned, according to the conventions prevailing in diverse academic communities, and notably on account of their presumed productivity in terms of analytical results. Each model may be developed into further multiple versions; no economist thinks that the specific model he/she is working on has the character of truth, or that it provides a theory of general validity. The canon of scientific procedure is a linguistic one: mathematical modelling. The standards in terms of conceptualization, evidence, interpretation are blurred, or not relevant at all. Complaints recur on the state of the discipline, or the pitfalls of some families of models; but there is no consensus on shared canons with which to validate models as regards their significance to build sound interpretations of historical evidence. The epistemological turn, as attested by the evolution of research practices, calls for debates on models and scientific explanations among scholars in economic philosophy and methodology.

This paper considers the 'explanation paradox' with especial attention paid to the recurring references to mathematical models as fictional narrations or engineering devices which deal with wholly artificial Wonderlands.

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[3] G. Israel extensively analyzed epistemological turns in the evolution of mathematical modelling (Israel 1996, 2015).

It highlights the dead ends towards which the extreme modelling freedom is leading, and the cultural impoverishment that it produces in the discipline.

2. Pluralism and Anarchy in Economic Theory. Building Castles in the Air?

Contemporary economic theory is going through a phase of fragmentation and anarchy. Models, and the accompanying interpretations, deal with issues in distinct fields of research, each using specific procedures and linguistic codes. There is no family of mathematical models that has the ambition of offering a global overview on the working of markets. In 2004, Colander, Holt, and Rosser Jr. convincingly argued that 'mainstream' theories in economics, as they are validated or explored in research by authoritative academic elites, are a set of evolving ideas (Colander, Holt and Rosser Jr. 2004: 486-487). There is no dominant paradigm of established ideas that constitutes a stable core of economic theory; mainstream economics is a "complex, adaptive system" that is "loosely held together by its modelling approach to economic problems"(Colander, Holt and Rosser Jr. 2007: 308). The empirical soundness of the theory of rational choice as inspired by Olympian rationality has been discredited by research in behavioural economics;[4] but the emergence of this new field, and studies on ideas of bounded rationality, have not discredited the mainstream models, which assume perfectly rational, forward looking agents. They live side by side in contemporary economics. Amidst the variety of hypotheses and interpretations validated by academic elites, the shared canon is mathematical language; mathematical modelling is mandatory as the standard requirement of the scientific approach, with priority over any reference to evidence, however defined, on the basis of statistical techniques or detailed knowledge from historical studies. In conformity with what T. Wolfe calls the high tide of 'scientificalization' in the humanities, scholars aim at showing up as hard scientists, to get recognition in the world of science and academia.[5] Scientificalization bias has advanced research towards mathematical complexity *per se* as the safest way to acquire academic prominence; it is the prime criterion for validating research at the edge.[6]

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[4] Herbert Simon named 'Olympian rationality' rational choice with no limits or costs in information gathering, in opposition to the idea of bounded rationality, or procedural rational choice under informational constraints.

[5] "Get hard! Whatever you do, make it sound scientific!" (Wolfe 2016: 87).

[6] "First, success in academic economics came from publishing 'hard' papers – meaning papers that used rigorous and preferably difficult mathematics". (Krugman 2011: 311).

Whatever the complexity of the mainstream, contemporary economic theory *par excellence* speaks the language of mathematical models, which are families of mathematical objects evolving under the joint pressure of the effort to produce robust analytical results and the effort to connect in interpretation their bare skeleton to some conceptualization of economic phenomena, or to presumed regularities observed in data. In current practice and interpretation, models are devices for logical investigation into fictional worlds.

An economic model is based on a mathematical skeleton subject to a number of logical requirements concerning the set of its primitive concepts, axioms, equations, or functional forms. The skeleton *per se* becomes a proper economic model when names and meanings are attached to its equations and functional forms, which are understood as building a world of conceptual interactions involving fictional agents or variables whose behavioural rules are specified by imposing structure on it. The mathematical skeleton is moulded by mathematical forms and the specific constraints imposed on them; its cognitive reading yields the conceptual picture of some fictional space of social interaction, notably some fictional economy. The second step requires the narrative arguing of some story about the interpretation of the fictional world in the model as it is explicitly suggested by the scholar who conceived it, or by other scholars developing or criticising the model in question. At the third cognitive step, the fictional characters interacting in the model's scenarios may be transfigured into situations related to actors and events in real economies, if any such interpretation is advanced.[7]

M. Morgan argues that the narrative which accompanies an economic model is not just a rhetorical or heuristic device; it is a crucial cognitive procedure that permits the use of the model to explore reality, and attributes meaning to its use (Morgan 2001: 361). The economic model combines deductive and narrative reasoning. Even in a static model, deductive logic on the structure of its mathematical skeleton is complemented by answers

[7] For a typical example, the reader is referred to the model in the article "Banking, Liquidity, and Bank Runs in an Infinite Horizon Economy" by M. Gertler and N. Kiyotaki (Gertler and Kiyotaki 2015). The authors name and define the fictional characters acting in the fantasy scenario that they build (artificial households, artificial banks); they impose their behavioural rules with the restrictions that they deem appropriate. Stories are narrated on the events which may happen in the artificial economy (e.g. events called 'banking distress', 'bank runs'). Numerical examples are provided to narrate the alternative paths of events in the model's context. In the last section and in the conclusion, the authors advance suggestions and 'insights' as regards the messages that the stories on the artificial economy convey in view of interpreting the real world of financial crises and economic policies. Occasional links to the real world are mentioned along with the fictional narrations.

and questions articulated in narratives to account for sequences of events in the fictional world that the model depicts, and their connections with dimensions of reality (Morgan 2001: 369). According to Morgan, the stories narrated on a mathematical model establish links with aspects of the real world, even if only by exploring a specific or typical case (Morgan 2001: 369, 377). If the stories told on models are a crucial component in the cognitive activity of building theories, their status is highly controversial. It is disputable whether they relate to occurrences in market societies, in past history or in contemporary times, or whether they just explain in narrative language what is going on in the artificial world of the model. The criteria adopted to associate models with narrative accounts related to real occurrences in the economic world are multiple and loose; different economists adjust them to their own epistemological views.

According to the criteria that M. Friedman proposed in his essay "The Methodology of Positive Economics" more than half a century ago, the validity of a hypothesis in economic theory should be tested by its predictive power, not by the conformity to realism of the specific assumptions adopted in advancing it (Friedman 1953: 5). A hypothesis is always descriptively false because it abstracts some crucial element from a mass of circumstances; it abstracts, however, from the complexities of observed phenomena with the aim of reaching a good approximation according to the interpretation the scholar has in mind (Friedman 1953: 8-9). Friedman conceived theory as "a body of substantive hypotheses" to be tested according to the criterion that they should be "sufficiently good approximations for the purpose in hand"; he downplayed logical consistency as a secondary concern (Friedman 1953: 5-6). Predictive power is the ultimate criterion of the effectiveness of each theory for the specific issue dealt with. This view is very distant from Walras's dream of discovering the both normative and scientific laws of markets; but theory is still conceived as the building of substantive hypotheses to be empirically tested. In Friedman's essay the anchorage of theory to reality is stronger than in the current practices of academic research in economics. Today the very notion of theory is in question: is an economic theory a coherent set of substantive hypotheses about what is going on in the world, or is it just a set of assumptions and theorems on the fictional interactions at work in the imaginary world of some fantasy 'economy'?

In the late 1970s, R. Lucas advanced looser requirements about predictive power as regards mathematical modelling in macroeconomics. According to Lucas, to build a model is to build some coherent 'artificial' economy created by scientific imagination to serve as a laboratory. The model builder provides the set of instructions that put together some clockwork economy, an engineering device mimicking the time series of actual economies.

The requirement is no longer the predictive power of a body of substantive hypotheses; it is the mimicking power that the "mechanical imitation economy" exhibits ex-post, in simulations showing that its artificial variables move in conformity with the overall trends of past time series (Lucas 1980a: 697). To test such mimicking, the scholar should establish a meaningful correspondence between some artificial variable in the analogue system and some relevant variable in the historical time series; but the ex-post conformity is not constrained by any strict condition of resemblance between the mechanical imitation economy and the real world of economic events. Since the 1980s, the real business cycle models that have transformed macroeconomics have been built on extreme 'as if' assumptions. Applying the technique of calibration, their mimicking power is checked on assigned values of parameters whose legitimate source in microdata and empirical validity are subject to heated controversies.[8] Macroeconomists have depicted fictional worlds of hermit economies with no pretence to providing good approximations in the representation of complex economic realities.

Does the looser requirement on mimicking substantially constrain the acceptable range of models admitted in economic theory? Empirical evidence is commonly considered a requirement of scientific theory in the natural sciences. Are historical evidence or predictive power important for contemporary mathematical modelling in economics? The answer is nuanced, but on the whole negative. In some fields, the mimicking requirement is an operational criterion for the selection of models in the evolution of theories; it dictates removal from the edge of research of the models that seem to fail it, amidst controversies on how statistically to assess sound evidence in sophisticated econometric research. In broad fields of research, no evidence requirements whatsoever are imposed on models either by the mimicking of historical time series or by any whatever conformity with observed evidence, *ex ante* on assumptions or *ex post* in historical interpretation.[9] Mathematical models are conceived as conceptual sets of instructions to build logical structures for the mere purpose of exploring fictional cases. They are not even conceived as analogue, clockwork systems; they are fictional castles in the air explicitly built for thought experiments.[10]

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[8] For a summary of the main controversies on real business cycle models, see De Vroey 2016, chap. 16-17.

[9] "Thousands of economic models have been adduced to explain real-world phenomena without ever having been tested in the lab or elsewhere". (Reiss 2012: 54). The example *par excellence* is the Arrow-Debreu model of general equilibrium; but exemples are available *ad libitum* from macroeconomics to microeconomics to game theory.

[10] In 1982, Sargent, describing his joint work with Wallace, spoke of a "spectacular" example built to show a patently artificial behaviour for the purpose of a thought experiment (Sar-

Thought experiment on fictional interactions is at the core of the game theoretic research that has won prominence in many fields of economics. In pursuing axiomatization in economic modelling, G. Debreu proposes an extreme view of modelization freedom by disconnecting the mathematical structure from interpretations; he gives priority to the axiomatic skeleton. The axiomatic theory, as the set of primitive concepts and the coherent system of axioms on which theorems are proven, may be applied to address questions on imaginary environments, which may be read as referring to ideal, economic contexts, the suggested interpretations being just "the last step of the analysis" (Debreu, 1986: 1265).

Neither the predictive nor the mimicking requirements discipline the freedom of imagination that is admitted in conceiving the stories attached to the mathematical skeletons. In principle, contemporary modelling practices admit whatever number of fictional economies may be created by the most various set of instructions, with almost no restrictions in terms of correspondence to actual behaviour, evidence checked on historical events, or accurate predictions. The generally accepted dominant rule is the conventional assumption of the forward-looking rationality predicated of the agents operating in the fictional economies. No longer a hypothesis about the behaviour of real economic actors, it is a technical model building principle justified by the rule of economy of means in scientific discourse, or left unexplained.[11] To paraphrase Mitja Karamazov's thorny question, without Olympian rationality does this "means everything is permitted now, one can do anything" in the economic Wonderlands?[12] The rationality assumption stands because outside its realm anything may happen in the fictional worlds of models.

The professional economist is an engineer who designs artificial 'economies' building the appropriate mathematical layout. When the aim is to change actors or interactions, the task is to coherently design some fictional world anew. As a consequence, in advanced research in economics, models are developed, or discarded with no regrets, according to academic fashion, promises of further results, or technical dead ends. At the close of his Nobel Lecture, Lucas moved away from R.E. equilibrium models with misperceptions and monetary surprises, declaring that they did not offer

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GENT 1982: 382, 387). In 1980, Lucas built an artificial cash-in-advance model to explain money theoretically; a large body of literature on money deals with models about artificial, trade interactions in wholly fictional contexts (LUCAS 1980b; LAGOS, ROCHETEAU and WRIGHT 2015).

[11] "John Muth's hypothesis of rational expectations is a technical model-building principle, not a distinct, comprehensive macroeconomic theory." (LUCAS 1981: 1).

[12] "Without God, and the future life? It means everything is permitted now, one can do anything?", in *Brothers Karamazov*, Part 4, Book 11, chapter 4.

a satisfactory theory of business cycles; it was time to look at the edge of research: the real business cycle models (Lucas 1996: 679-680). The discarded models had originated a vocal revolution in macroeconomics that had been claimed to be a radical turn introducing major theoretical innovations. They were dismissed in a few lines.[13]

3. The Status of Models in Contemporary Economics: Hard Science or Fantasy Fiction?

In 1997, Solow, addressing questions of method in macroeconomics, underlined "the model-building philosophy that motivates and guides economics", differentiating economics among social sciences (Solow 1997: 55). In his description, he proposed a simplified vision of the approach that in methodological debate is named the 'isolationist view' (Solow 1997: 46). He anchored mathematical modelling to the strategic simplification of 'causal arrows' in economic reality, with the ultimate aim of illuminating what goes on in the world.[14] The isolationist view underlines the nature of models as simplified representations able to isolate crucial aspects of the economic world in an abstract theoretical frame (Grüne-Yanoff 2009: 1). Along separate paths, N. Cartwright and U. Mäki developed the isolationist view with explicit reference to J. S. Mill, and to ideas of method inspired by natural sciences (Mäki 2009; Cartwright 1998, 2009). According to Mäki, the model builder constructs a surrogate system that aims at representing some outside target system. In the surrogate system, scientific representation is to be distinguished from resemblance; it admits, and requires, the procedure of isolating the causal factors or mechanisms which appear most relevant.[15] The modeller manipulates assumptions to serve the purpose of

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[13] From the historical perspective, the passage at the edge of research from R.E. models with misperceptions to real business cycle models was promoted both by the adoption of new modelling technologies and by the failure of previous R.E. models to satisfy the mimicking requirement.

[14] "A model is a deliberately simplified representation of a much more complicated situation. (…) The idea is to focus on one or two causal or conditioning factors, exclude everything else, and hope to understand how just these aspects of reality work and interact." (Solow 1997: 43).

[15] "Models represent in two ways, both of which require the model to be a model of something else. First, to say that a model is a representative of some target is to say that it stands for that target as its surrogate. (…) M resembles, or corresponds to, the target system R in suitable respects and sufficient degrees. This second aspect of representation enables models to serve a useful purpose as representatives: by examining them as surrogate systems one can learn about the systems they represent. However, one might also fail to learn about the target by examining the model, but this should not be taken to imply that there is no representation.

isolation and focus the attention on the relevant strategic links (Maki 2009: 30). Many problems are open in the isolationist view when applied to explanation in the social sciences, since in social life the causes may not be separable, or they cannot be neatly isolated as in laboratory experiments. It certainly fails to portray how today economists work in mathematical economics.

Mathematical economists do not focus on isolating the main causal factors or mechanisms; notably so scholars in advanced macroeconomic theory. The dominant epistemological paradigms dictate requirements of consistency or robustness; assumptions are selected more for mathematical convenience than to satisfy isolation causality, since the mathematical skeleton should provide theorems in terms of equilibrium or dynamic properties.[16] Contemporary mathematical modelling in economics is a complex set of cognitive practices that fail to be inspired by the neat isolation of some causal factors or reproduce experiments involving isolation (Knuuttila 2009: 60; Grüne-Yanoff 2011).

Methodological debate reflects the change of focus ongoing in research. Among scholars defending the isolationist view, the assertion prevails that the narrative reasoning attached to economic models says something about the real world. Conversely, the prevailing fictionalist views signal the artificial nature of models, telling stories born from the imagination.[17] Models are variously compared to literary narratives, where imaginary contexts tell us something about life. References to parables, fables, fairy tales, novels are suggested by scholars dealing with their own work, or in debates on method (Gibbard and Varian 1978; Morgan 2001, 2007, 2012; Rubinstein 2006; Grüne-Yanoff and Schweinzer 2008; Sugden 2000, 2009). The roots of economic theory in historical interpretation being lost or severed, mathematical economists turn into fantasy-writers, notwithstanding their scientific ambitions; they build up parallel worlds that they freely explore in the mind, as do writers and readers of literary fiction.

A. Rubinstein, an outstanding scholar in game theory, maintains that in building game-theoretic models, economists narrate fables (Rubinstein

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Representation does not require resemblance: it only requires issues of resemblance to potentially arise". (Maki 2009: 32).

16 The representative household assumption is almost ubiquitously adopted in macroeconomic models, although the conditions for aggregate behaviour to correspond exactly to that of some representative agent are very restrictive (Hendry and Muellbauer 2018: 295). Linearity assumptions are adopted when non linearity would increase mathematical complexities, or generate intractable dynamic behaviour. Stability assumptions are postulated. And so on and so forth.

17 The nature of the divergence is a matter of controversy. See the debates in *Erkenntis*, n. 7, 2009.

2012). An economic fable is a short story couched in common language that narrates the imaginary situation in which fantasy characters act in a fantasy context; the economic fable deals with their interaction in behaviour assuming they are motivated by self–interest.[18] The story is based on the model's mathematical skeleton; thanks to intuitive judgement, the economic fable teaches something about situations in the real world which scholars or readers might happen to face or be involved in.[19] The insights furnished by rigorous mathematical analysis are placed at the same cognitive level as the pearls of wisdom that a centuries-old tradition in narration ascribes to fables.

> The word 'model' sounds more scientific than 'fable' or 'fairy tale' although I do not see much difference between them. The author of a fable draws a parallel to a situation in real life. He has some moral he wishes to impart on the reader. […] We do exactly the same thing in economic theory. A good model in economic theory, like a good fable, identifies a number of themes and elucidates them. We perform thought exercises that are only loosely connected to reality and that have been stripped of most of their real-life characteristics. However, in a good model, as in a good fable, something significant remains (Rubinstein 2006: 881).

To stand on sound ground, R. Sugden conducts a comparison between models in economics and realistic novels which narrate what happens in the fiction of credible worlds. Economic models explore 'self-contained imaginary worlds', with no claim to providing simplified pictures of aspects of reality, not even in abstract, symbolic language (Sugden 2009: 17). Novelists make their 'realistic' stories credible to the readers; mathematical models in economics are constructions of "credible counterfactual worlds" (Sugden 2000: 28).

> Credibility in models is, I think, rather like credibility in 'realistic' novels. In a realistic novel, the characters and locations are imaginary, but the author has to convince us that they are credible – that there could be people and places like those in the novel. […]. (Simplification and isolation are allowed, of course; we do not expect to be told everything that the characters do or think. But what is being simplified is not the world of actual events, but the world imagined by the author) (Sugden 2000: 25).

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[18] "A description of an economic model is like the introduction in a tale, presenting the heroes, their interests and the setting in which they operate". (Rubinstein 2012: 19). Rubinstein fails to specify the distinction between fables and fairy tales, on which ample debate exists in literary studies.

[19] "We will take the tale's message with us when we return from the world of fantasy to the real world, and apply it judiciously when we encounter situations similar to those portrayed in the tale". (Rubinstein 2012: 16).

Other scholars speak of case-based knowledge. They maintain that economic theorists cannot claim to propound substantive hypotheses or conjectures of general validity. Their aim is not to furnish accurate description. Economic models explore thought experiments about fictional cases that may "convey a message". The knowledge acquired should be conceived as case-based reasoning, from which conclusions about similar cases in reality, if any, may be inferred, the inference being based on the assessment of resemblance to the theoretical case (Gilboa, Postlewaute, Samuelson and Schmeidler 2014: 516). Theorists conjecture that their models are used by other people to infer insights about situations occurring in the real world; but they are not required to advance any such inference when building the mathematical fictions born from their imaginations (Gilboa, Postlewaute, Samuelson and Schmeidler 2014: 519). The model stages a hypothetical set of events, and its story is never wrong. Under some scientific varnish, the idea of case-based knowledge is again evocative of fables or fantasy fictions. The theoretical case born from the theorist's imagination conveys insights to help understand economic reality; but it may be spectacular, or exemplary, or plainly unreal. The audience of 'practitioners' makes the inference, if they so wish; the readers will take care of it if that is the case.[20] In radical interpretation, provided that the stories are well built in mathematical language, it is not the aim of trained, academic economists to suggest how to draw conjectures. The theorists are spared the effort at inductive inference, whatever the cognitive procedures with which it might be reached; in principle, the validation of a canon for sound inference lies outside their expertise and tasks.[21]

If economic theorists fail to specify the cognitive instruments with which their audience should connect fictional cases to the explanation of real occurrences, a question legitimately arises concerning the faculty of judgement to assess resemblances and to draw inferences. Is it innate intuition, or does it depend on rational, procedural checks? Are audiences

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[20] "As stated, the example can be viewed as the claim, 'I have observed a case in which idealised agents, maximizing expected utility, with the following utility functions and the following information structure, behaved in such and such a way'. The relevance of this observation for prediction will depend on the perceived similarity between the idealised agents and the real agents one is concerned with, the similarity between the situation of the former and that of the latter, and so forth. An economist who is interested in real agents would therefore have to judge to what extent the situation he studies resembles the idealised situation in the 'case' reported by Akerlof; see Sugden (2009), who argues that it is the reader who must make the mapping between a model and the reality it models." (Gilboa, Postlewaute, Samuelson and Schmeidler 2014: 518).

[21] "The common practice in economic theory is to use models without a clear specification of the similarity function that should be used to apply them to concrete problems." (Gilboa, Postlewaute, Samuelson and Schmeidler 2014: 519).

trained to reach sound assessments on similarity? Who are the experts, if any, who might train them to infer sound conclusions? Sugden trusts the credibility property as a warrant for good inductive inferences from the credible, counterfactual worlds to the real world (Sugden 2000: 28). However, as Reiss effectively underlines, the credibility *per se* of some proposition among a group of researchers does not guarantee that a sound explanation is advanced.[22] Historical studies on the evolution of economic theories plainly show how prominence is gained or lost in academic communities for reasons including ideology, visibility, and power; issues of technical tractability are prominent in validating the success of models among academic elites. An alternative interpretation suggests that the credibility of models should be checked through robustness analysis (Hands 2016; Lisciandra 2017; Kuorikoski, Lehtinen and Marchionni 2010). Robustness analysis, strictly a mathematical criterion, is interpreted as being a requirement on the overall stability of the results reached in some family of models, when changing one or more specific assumptions. It suggests interesting evaluations, considering the proliferation of multiple versions of similar models in academic literature, once a line of research is acquiring prominence. Since it aims at specifying the canon of assumptions unifying a family of models, on which their main results stand, it helps to reach judgements on the consistency of a line of research in mathematical economics. However, it cannot resolve the issue about how to reach sound judgements on the relevance of fictional models for explanation, and their clues to understand real occurrences. In a historical perspective, as a criterion to assess lines of research, it should be complemented by deeper conceptual analysis of the evolution of progressive or degenerative research programs.

In these debates, the differences between literary narratives in their rich variety and mathematical models in economics are poorly accounted for (Ingrao 2015). Let us just note that in literature credibility is relevant well beyond realistic novels, or echoes of immediate resemblance. J.R.R. Tolkien was meticulous in conceiving the Middle-earth. Literary credibility has multiple dimensions, including psychic coherence in characters, in continuity or change, and the sequences of crucial events. Writing well-constructed stories is a major task in storytelling that is appreciated by both readers and literary scholars. Moreover, the superficial comparisons between models and literary writings fail to explore the cognitive and emotional process by which literary narrations are enjoyed, and whether a rich plurality of

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[22] "Many factors affect judgements of credibility, most of which have no essential relationship with explanatoriness: the specific experiences and values of an individual, his or her upbringing and educational background, local customs and culture, social norms and etiquettes of a community of researchers, its theoretical preferences and history" (Reiss 2012: 56).

meanings live in their stories. If the grasshopper dies because it has no food in the cold season, should the readers infer that it is good to save for the winter, or that our neighbour will die if we are not compassionate? Does the fable suggest that songs give plenty of joy? Literary narration does not aim at dictating catechismal precepts; on the contrary, fables, fairy tales, stories, fantasy fiction or realistic novels freely explore the challenges, the conflicts and vagaries in human identities and human lives. Their fascinations and their messages are decoded anew with changing values and historical experience. Tolstoy, when asked about the meaning of his novel *Anna Karenina*, declared that to express it he should have to rewrite the whole novel (Propp 1966: 222). Fables, fairy tales or fantasy stories, much as realistic novels, treasure multiple layers of meanings, which are explored with the clues offered by the cultural heritage of custom, ethics, and the humanities.

What are or should be the cultural sources on which judgements about credibility, resemblance, or other forms of inductive inference are assessed as regards mathematical models in economics? They are left in the shadows.

4. The Honest Disclaimer and its Violations

Sugden proposes the crucial question neatly: do models build a bridge towards understanding the real world? He acknowledges that the gap between mathematical models in economic theory and the real world is wide, and difficult to bridge in rigorous ways[23]; economists often hide it by 'rhetorical devices', but somehow a transition has to be established.[24] The controversial bridge calls into question the insights that models convey, and their foundations on sound cognitive procedures. What are the cognitive processes by inductive inference, by resemblance or analogy that should build the transition from the infinite variety of fictional Wonderlands in models, and the stories narrated on them, to the explanation of economic events in past history or in contemporary societies? The significance of building mathematical models depends on this question; but the recommended steps, checks, or constraints are vague. Neither shared practices

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[23] "Economic theorists construct highly abstract models. If interpreted as representations of the real world, these models appear absurdly unrealistic; yet economists claim to find them useful in understanding real economic phenomena. This prompts the question: Do these models really help us to understand the world, and if so, how?" (Sugden 2009: 3).

[24] "Somehow, a transition has to be made from a particular hypothesis, which has been shown to be true in the model world, to a general hypothesis, which we can expect to be true in the real world too" (Sugden 2000: 19).

are validated in the profession as sound scientific procedures, nor is focal attention devoted to the issue in academic communities.[25] Authoritative scholars skip the passage, confining it to a sphere of language other than scientific language proper. We are even told that it is not a major task for economists as model builders to address the issue. The scientific reasoning that mathematical language admits is about the stories told on the mathematical skeleton, and their inner logic. It has nothing to do with the world. Here is the answer R. Weintraub proposed to T. Lawson, in a polemical discussion in 2005.

> In general, both equilibrium and stability (in the sense that any trajectory of the dynamic system initially 'near' equilibrium converges to equilibrium under the system's dynamic laws) are features of the model. And as Dorfman et al. (1958, p. 351) said so directly, "It is the model we are analyzing, not the world". So much for terminology. (Weintraub 2005: 448).

The bridge should be neither built nor crossed: it is, to paraphrase Wittgenstein, unspeakable, and thus not to be spoken of. A disturbing conclusion follows. The economist building a mathematical model somehow pertaining to the field of economics has the right to disclaim any responsibility for proposing sound interpretations which connect it to aspects of reality as a cognitive device relevant for reading what goes on in the world, events in contemporary history or appropriate policies. The messages on issues of economic policy have no pretence to the same logical rigour reached in dealing with policies in the fictional models.[26] Although the aim of macroeconomics is to deal with policy issues, no robust, rational arguing is anchored to the stories narrated in mathematical models to speak on economic policies in the real world. As self-contained worlds, models are never wrong, provided the mathematics is correct.

First, one need not wonder why economists feel that they gain insights and understand economics better using models, whose assumptions are wrong. In the case-based approach, models cannot be wrong. As long as the mathematical

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[25] "In economics (and perhaps, as the example from biology suggests, in other sciences too) there seems to be a convention that modellers need not be explicit about what their models tell us about the real world. Given this convention, it is hardly surprising that the question of what role models play in economics is controversial among methodologists" (Sugden 2009: 16).

[26] "At the beginning of this talk, I said that my main purpose was to discuss connections between policy in the model I was about to set out and policy in the United States, today. My experience is that an economic model, if it is concrete enough to be visualized, has a life of his own, and people will draw such analogies between it and 'reality' as they find helpful, quite independently of how one might wish or try to direct them. I will sketch the connections that seem clearest to me, but with the understanding that they cannot be established on the same logical level at which we can understand the internal workings of the model itself" (Lucas 1986: 129).

analysis is correct, a theoretical case is valid, the same way that an empirical or experimental case is valid as long as it is reported honestly and accurately. Cases do not make any claim to generality, and therefore they cannot be wrong. (Gilboa, Postlewaute, Samuelson and Schmeidler 2014: 520).

Should theoretical economists assume responsibility for the results which they predicate in the mathematical models that they disseminate? In principle, like model engineers, they speak rigorously only about the fictions that they conceive as self-contained imaginary worlds or theoretical cases. They are not primarily concerned with the applied significance of the cases that they explore on assumptions which might prove wrong if related to some external economic reality. Are they accountable for providing sound interpretations as regards the insights that the models which they build convey on events in economic history, or on policies to be adopted in real circumstances? In principle, they speak rigorously only about what goes on in the artificial clockwork models. The rest is silence; or it is talk, with no pretence to rigour. This is the strict, paradoxical conclusion of such epistemological premises.

Some scholars defend the principle of transparent fairness in being unaccountable for interpretations with honest strictness. Rubinstein has pronounced a fully honest disclaimer. He trusts game theoretic models only as far as they provide rigorous reasoning on abstract strategic interaction; he does not trust them at all as providing solutions on issues of economic policy (Rubinstein 2012: 129). The honest disclaimer sheds disturbing light on the social utility of economic theory. One might wonder in what consists the advantage of mathematical modelling if the constructive addition that models provide to our knowledge for improving economic policies is so poor. Moreover, the disclaimer has a corollary: why should mathematical language *per se* be a canon of scientific advancement? Speaking in mathematical language performs the magical trick…the magical words irrespective of the substantive knowledge. The disquieting conclusion should follow that professional economists abdicate pretensions to offer suggestions based on richer knowledge than laypersons have.

They know the technical cogs in clockwork models, but they can barely suggest 'insights' or 'connections', if any, on events and policies. Since their understanding of the world is not improved by the practice of rigorous modelling, since they cannot rigorously infer messages from their mathematical fables, should we trust them as being rational in their inductive judgements, and under what meaning of rationality?[27]

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[27] On the strictures of the meanings of rationality in economics, see Ingrao 2014.

In fact, in the profession, the exceptions to the honest disclaimer are many, and repeated. It is a defensive device against charges of building models on patently false assumptions, or of fancying about amazing Wonderlands; but it is most often not respected, and notably so by the scholars in macroeconomics (De Vroey 2016: 304 ff.). E. Prescott violates it repeatedly.[28] Lucas, ambiguous on the disclaimer, is not always cautious in proposing interpretations.[29] Theoretical economists do not know how much of their 'expertise' as model builders might be "transferable to the conduct of policy in the world of today", a "difficult question", to use Lucas's own words.[30] He suggests that patently false or misspecified models convey messages, and in his retrospective view on his own theoretical work, he emphasises the effort to shed light on pressing monetary issues (Lucas 2013; Sargent 2015: 55, 56). In recent debates on the state of macroeconomics various scholars have promoted the use of highly fictional DSGE models tested by calibration techniques as instrumental in formulating quantitative policy advice to monetary policy authorities (Christiano, Eichenbaum and Trabant 2018).

5. The Controversial Bridge: One or Many Languages in Economics?

Such a contradictory state of the art in economics is inherent in the exclusive emphasis placed on mathematical sophistication as the primary aim in theoretical work, and the dominant criterion to assess scientific rigour. In fact, the bulk of the contemporary economic literature is learned narrative prose that as such is not recognised as 'scientific' discourse. Both inside and outside academia economic discourses in narrative prose flourish, forming

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[28] "The increased stability of the economy and the improved performance of the payment and credit system may be due in part to the diffusion of findings of Finn's and my "Rules Rather than Discretion" paper. People now recognize much better the importance of having good macroeconomic institutions such as an independent central bank" (Prescott 2004: 375). He made such a strong assertion in his Nobel Lecture, three years before the global financial crises. Many passages in Prescott's writings signal that he interprets the results of fictional models as stating plain truths about reality (De Vroey 2016: 304 ff.).

[29] De Vroey found interesting notes on methodology in Lucas's archives; but he notes: "However, in his published papers, Lucas gave no clue as to what he meant exactly" (De Vroey 2016: 178).

[30] "I will begin by considering the dynamics of policy in the context of a specific, necessarily very simple, general equilibrium model. This will occupy most of my time and when I am finished, we will have arrived at a fully understood consensus as to how monetary and fiscal policy ought to be conducted in this artificial society. Then we can turn to the more difficult question of determining how much of this expertise is transferable to the conduct of policy in the world of today" (Lucas 1986: 1-2).

a large body of literature addressing controversial issues and heated debates on policies. In textbooks, in essays, in articles for the press, narrative prose forms the backbone of the discipline; it is influential in spreading persuasion on currents of ideas, definition and conceptual understanding of theories, intelligence of events, appropriate policies. Narrative prose systematically accompanies model building, being crucial for bridging the gap between the imaginary worlds in theoretical economics and the reality of economic events. The fictional worlds in models acquire life thanks to narratives which go beyond formal properties, evoking resemblance to real economic phenomena[31] (Gibbard and Varian 1978; Grüne-Yanoff and Schweinzer 2008; Morgan 2007, 2012). The "narrative account of events" attached to game theoretic models plays a primary role in conceptualization, and in the articulation of questions and answers (Grüne-Yanoff, Schweinzer 2008: 136, 140; Morgan 2012: 344 ff.).

It is not clear where these narratives come from, and for what reasons one is preferred to another. Debreu's view of the axiomatic approach is silent on the source of primitive concepts, and why the scholar should impose specific restrictions on the axioms. If they are intended to be tales exploring the fictional cases portrayed in the models, their interest is questionable as regards the discipline of economics proper. If they are covertly or explicitly predicated as credible stories, somehow connected to real events in the economy, by what sources is their credibility established? What is the lexicon that they use? Are they inspired by the heritage of shared culture in other fields of economic discourse outside economic theory proper? Are they influenced by the literature in economic history or the history of thought? Indeed, Lucas's Nobel Lecture is a learned discourse on the quantity theory of money with references to the history of thought, statistical evidence, and controversies on policies. To be assessed, the fictional worlds of models require the prose of economic culture, a specialist language with philosophical roots and ideological echoes, built in long controversies on interpretation and historical reconstruction.

Eventually, the complexity of building inferences comes to light, involving ideas, values, background in historical knowledge, and the perception

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[31] "We will argue that the game structure and the model narrative *together* constitute a model of an economic situation. We call this the game model. […] While there is widespread agreement that game theorists engage in the practice of telling stories when teaching or presenting new game models, it is more controversial whether this narrative is part of the game model in the more substantial sense claimed above. In this section, we discuss the different functions that narratives have when using game theory to model economic situations. We argue that each of these functions is *necessary* for the use of game theory as an economic model, and that therefore the narrative is a necessary part of the game model" (Grüne-Yanoff and Schweinzer 2008: 136).

of fruitful exchanges with other fields of culture. When scholars openly address the issue of sound reasoning, the complexity of what theory is in economics becomes apparent if theory is understood as a body of argued explanations to improve the understanding of economic realities, and not just the exploration of self-contained fictional worlds. At the core of economic theories, conceptualization requires coherence in specialized language going beyond the proof of theorems on mathematical objects. Concepts in economics arise from deep roots in the history of economic ideas, which have connections with philosophy and the debate of ideas in the humanities at large. They cannot be severed from these roots and links. Ideas such as price, good, choice, competition, equilibrium, welfare, equity, growth, development, to give but a few examples, cannot be properly understood when severed from the wider cultural heritage to which they belong, much like the narrative interpretations which use them to speak about events in the real world. Because the status of economic discourses in narrative prose is not being properly recognized in academia, if not as subsidiary or didactic or merely lavish, its canons of rigour remain unchecked and in the shadows.

Are contemporary theorists in economics hard scientists on their own methodological criteria, or are they storytellers or fiction writers like the despised scholars in the humanities? Neither of the alternatives work. We cannot go back to the nineteenth-century search for truth in mathematical modelling; but we cannot accept the final dissolution of economic theory into dispersed fragments of arbitrary Wonderlands, whose contact with reality are so ill-defined that theoretical economists end up refusing to assume responsibility for what they might suggest in terms of explanation and policies. The economic mainstream, with its controversial, evolving core, should not be defined by the dominance of mathematical modelling. It cannot rely on economic fables disconnected from both evidence and intelligence of the real world. Thus, we should rebalance the primacy of mathematical language in economic theory. To dare cross the controversial bridge, we should acquire, and assess, knowledge from multiple languages, sources, inquiries. This is the only rational strategy with which to address the complexity of historical events in changing societies, which is the aim of economic culture to enlighten. To check by inference the credibility of fictional economic stories, to propose substantive interpretations, or to creatively conduct economic policies – all tasks that the economic profession must undertake – sound economic theory should be rebuilt in learned narrative prose rooted in various languages of culture, in intensive dialogue with research in economic history or history of thought, and with the joint support of learned exchanges with philosophy and the humanities.

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