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Economic models, realism and similarity

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ECONOMIC MODELS, REALISM AND SIMILARITY

Similarity
Economic models
Mechanisms
Possibility tree
Substantive assumptions
Domain of applicability

In the present paper it is argued that differences among economic models are basically differences in their selected part of the real world these models try to account for. Therefore, their range of applicability to a target system turns out to be important for their selection to particular purposes. In this respect, an approach based on the similarity of models to a target system and to the modelers' purposes is provided. It is also argued that models vary in values of similarity. These values will help agents to select the model that best meets the role of examining some phenomenon of interest.

Modelos económicos, realismo y similaridad

Semejanza
Modelos económicos
Mecanismos
Árbol de posibilidades
Supuestos sustantivos
Dominio de aplicabilidad

En el presente artículo se argumenta que las diferencias entre los modelos económicos son básicamente diferencias en la parte seleccionada del mundo real que estos modelos tratan de explicar. Por lo tanto, su rango de aplicabilidad a un sistema objetivo resulta ser importante para su selección para propósitos particulares. A este respecto, se proporciona un enfoque basado en la similaridad de los modelos con un sistema objetivo y con los propósitos de los modeladores. También se argumenta que los modelos varían en valores de similaridad. Estos valores ayudarán a los agentes a seleccionar el modelo que mejor se adapte a la función de examinar algún fenómeno de interés.

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Índice

1. Introduction

In economics, model building is a fundamental aspect of scientific research. Numerous epistemological approaches have attempted –albeit unfortunately without any consensus yet– to conceptualize both the nature of these models and the type of knowledge they provide for different purposes (*e.g.*, intervention, explanation, prediction, representation, etc.). Models such as "isolations", "nomological machines", "artifacts", "fictional worlds", "analogous systems", "caricatures", "conceptual explorations", "mediators" and many other epistemic approaches have tried to understand what economists do when they build their models.

Economic models make use of numerous distortions, many of them highly controversial. As a consequence of that, inside the discipline there exists an endless debate about whether models inform us something about the behavior of real agents, the job market, the means of production, etc., or if they are just more intellectual games or imaginary worlds without any use for pragmatic purposes, such as explaining or predicting economic phenomena or applying a socioeconomic policy. The controversy generated in relation to this issue is not minor. For some scholars, economics is a contested scientific discipline: not only its theories and models are contested, but also its status as a science (Mäki, 2002a).

In addition to this, economic models seem to suffer from external validity problems. Cartwright (2009) has already warned about this point. More precisely, the author maintains that, unlike some disciplines such as physics or astronomy, economics lacks sufficiently robust and universal principles to infer results. As a result, economists need to introduce a significant number of "structural" assumptions. The problem with this is that the results derived from these models will be strongly conditioned by that structure imposed in advance. Therefore, economic models gain in internal validity, but to the detriment of external validity.

In the present paper it is expected to show that these two problems are intimately related. Specifically, it is argued that economic mechanisms do not refer to something universal and/or stable, but depend on a set of very precise (structural) conditions to be met beforehand. Models attempt to give account of different economic mechanisms, and they make explicit assertions about these structural conditions. The problem is that such assertions "constraint" the models' domain of applicability. To make things worse, some of them may sound "unrealistic", for referring to descriptions that are unlikely to be met in the real world.

In this sense, the so-called "unrealism of assumptions" in economic models might be interpreted in a different way. It is not that assumptions such as perfect competition, full employment, immobility of factors between countries or rational expectations are necessarily "unrealistic", but that their domain of applicability is, perhaps in most of the cases, not congruent with what happens in the daily real world. Yet it does not mean that some economy or market may work very close to full employment or to perfect competition.

For this reason, it seems more appropriate to think of models according to their level of *similarity* with the selected part of the world about which modelers are expected to say something. Different models describe different economic scenarios. These scenarios should be compared with the target system. This is when the idea of "similarity" becomes relevant. For instance, an international economic model that assumes constant terms of trade will lack explanatory capacity if, in the target under study, these terms are going down. These models would not be "similar" to such target systems. However, this does not imply that they are false and that they should be dismissed. On the contrary, there may be real world scenarios that, actually, bear a greater similarity to what is asserted in these models. *Similarity* would therefore be a criterion for choosing between models that are most useful to explain a certain phenomenon, and not to demarcate which of them is true and which are false.

The paper is articulated in the following way. In the next section the neoclassical model of international trade and its alternative scenarios are presented. The conditions that need to be met for its right working and the alternative mechanisms that may emerge as long as some of these conditions are not met are shown. In point three it is argued that all these scenarios may be conceptualized within possibility tree diagrams: there is a multiplicity of courses of action or alternative paths that can be followed —in terms of possibility—after activating a particular causal factor. Without the pretension of providing an ontological stance about economic entities, in this section it is only expected to show that incorporating possibility tree diagrams into the economic analysis may facilitate the understanding of many economic phenomena, specially those which are examined in the light of theoretical models. In section four, different kinds of assumptions used in economic modeling are examined. It is argued that a particular sort of assumptions is crucial for determining which path of a possibility tree an economic process or phenomenon can follow. In section five it is shown that the discussion about the relationship between economic models and the way they provide information about the real world is more related to their chance of being applicable to different real-world scenarios than to a matter of verisimilitude or truthfulness. In this regard, the similarity between models and the target system is key, since it is such similarity what allows agents to select, from a menu of models, those which best accomplish a particular purpose. The paper ends with a reflection on the use of models.

2. The Neoclassical Model of International Trade (NMIT) and its deviations

Following the Ricardian concept of *comparative advantages*, the NMIT shows that countries may benefit from international trade. The assumptions of the NMIT are as follows:

1. There are only two countries.
2. Each country produces and consumes only two goods (x and y).
3. There are two agents: consumers and producers.
4. Consumers maximize their utility and producers maximize their profits.
5. There is a perfect competition market.
6. There are no transport costs or official barriers to trade.

7. Countries have different relative prices.

8. There is mobility factors within countries but not across them.

Both in autarky and open to world trade, the productive activity of countries is carried out on the production-possibility frontier (PPF), which is determined by the relation between the cost of inputs and the price of goods. The producer's equilibrium point is the place where the ratio of marginal costs of goods is equal to the ratio of prices. At this point, producers have no incentive to change their level of output, because the price they receive for each good is the same in relation to its marginal cost.

Consumers are also optimizing agents, so they will choose the set of goods x and y that maximizes their utility. Such maximization takes place where the ratio of relative prices of goods is equal to the ratio of marginal utilities of goods. Therefore, the equilibrium point of a country in a complete state of autarky is that where the ratio of marginal utilities of goods equals to the ratio of marginal costs of goods.

Let us now suppose that a country abandons its autarky. Its incorporation into international trade implies that this country is exposed to a new set of relative prices (assumption 7). As the relative price curve changes, countries are going to readjust their pattern of both consumption and production. Let $(P_x/P_y)_1$ be the relative price of the home country. This country faces the international terms of trade $(P_x/P_y)_2$. For the sake of simplicity, it will be assumed that $(P_x/P_y)_1 < (P_x/P_y)_2$. As can be seen, the relative cost of good x (that is, the cost of x in relation to the cost of y) is lower for the home country. Therefore, it has a *comparative advantage* for good x (that is, the home country is relatively more efficient in producing x than in producing y) and consequently a *comparative disadvantage* for good y.

For the producers of the home country, the price of x is relatively higher in the international market, so they will end up producing more units of good x and fewer units of good y.

Consumption also changes under the new relative prices. Thanks to being open to international trade, consumers receive more benefits than their productive capacity. In autarky, the PPF was equal to the consumption-possibilities frontier (CPF). With the commercial opening, the domain of the CPF is bigger than the domain of the PPF. Two effects are involved in this process. On the one hand, there is a *substitution effect*, which arises as a consequence of the change in relative prices: since the relative price of x increases, agents will consume fewer units of good x and more units of good y. There is also an *income effect*: since the home country specializes in the production of good x and since its relative price increases, then there will be an increase in the real income.

Nevertheless, the assumptions of the NMIT should not be thought of as universal principles that rules the totality of social systems. On the contrary, they just define a possible path or scenario, that is to say, a possible mechanism among many other mechanisms.

A clear example of this is the assumption of non-mobility factors among countries. Such an assumption could have been verisimilar in the time of Ricardo, but not today. Foreign investments are very common nowadays. We could think that the assumption of non-mobility factors among

countries is irrelevant for the NMIT's results, so that changing it for another more realistic assumption would not affect the robustness of such results. But this is not so. According to Emmanuel (1972), the foreign investment process produces an unequal exchange that favors the investor country, although to the detriment of the investment receiving country.

For Emmanuel, massive capital movements are a consequence of the different returns between countries, which in turn depend mainly on wage differences. For the sake of clarity, let us suppose two countries A and B. In country A wages are higher than in country B, which encourages foreign investment from A to B. Since the rate of profit in A is lower than in B, firms from A are able to offer their goods in B at a lower price than the local prices. Despite that, it is likely that their rate of profit continues to be higher than the rate of profit in A. Clearly this scenario will be prejudicial to local producers in B, as their rate of profit will be lower. Also, the decrease of prices in B brings about a deterioration of its terms of trade, worsening its trade balance. As can be seen, Emmanuel's model yields a result that markedly differs from the NMIT's result: international trade benefits country A, but such benefit is to the detriment of country B. Emmanuel modifies a few assumptions of the NMIT and observes what consequences can be derived from a process of foreign investment.

Shaik (1979, 1980), on the other hand, asseverates that the Ricardian mechanism of comparative advantages is false on its own fundamentals. Shaik considers that the quantity theory of money is implicit in this mechanism [1]. Regardless of the inefficiency of a country, the prevalence of this theory enables the fact that its absolute disadvantages turn into comparative advantages.

Instead of assuming that there exist mobility factors among countries, let us only recall that prices in country $\boldsymbol{B}$ are lower than in country $\boldsymbol{A}$. Such discrepancy may be attributed to several factors (differences in wages, technology, taxes, etc.). Let us keep the assumption that there are only two goods (x and y). Shaik claims that, at the beginning of the trade, $\boldsymbol{A}$ will import both goods from B. $\boldsymbol{A}$ must pay its imports in gold, dollars, or another foreign currency. Such payment generates a decrease in the central bank's reserves of $\boldsymbol{A}$. If the quantity theory of money is what rules, then the fall in reserves will bring about a decrease in money supply, which in turn will lead to a decrease in the price level.

The contrary occurs in $\boldsymbol{B}$. Since $\boldsymbol{B}$ exports both x and y, its central bank's reserves increase. The enhancement in such reserves generates an increase in money supply, which in turn leads to an increase in prices of both $\boldsymbol{x}$ and $\boldsymbol{y}$. This mechanism will continue to hold until, at some point, $\boldsymbol{A}$ ends up producing a commodity cheaper than some commodity exported by B. The adjustment in the monetary variables allows $\boldsymbol{A}$ to go from *absolute disadvantages* in both goods to *comparative advantages* in the production of one of them.

However, Shaik argues that the notion of comparative advantages does not hold if the quantity theory of money is replaced by Marx's theory of money. According to the latter, excesses or deficiencies of money are manifested as increases or decreases in the central banks' reserves. If reserves increase —as occurs in $\boldsymbol{B}$—, central banks will try to convert their reserves into capital, so there will be a decrease in the interest rate. Such decrease will make credits cheaper, so there will be a stimulus for expanding investment and consequently employment and production.

If what rules in a target system is Marx's theory of money, then neither the Ricardian mechanism of comparative advantages nor the benefits of opening to international trade will work. Specifically, the imports of country ***A*** will cause a decrease in its central bank's reserves. This decrease will produce an increase in the interest rate, which will lead to a drop in investment. The final result will be a decrease in the local production of goods. Making things worse, this effect will be increased by a decline in local production that occurs as a consequence of the absolute disadvantages: it is cheaper to import goods from ***B*** than to produce them in ***A***. Thus, free trade will only produce benefits for ***B***, although to the detriment of ***A***, which will succumb to chronic trade deficit and mounting debt.

Finally, instead of changing some of the NMIT's assumptions, we could examine the intertemporal functioning of the very model. In doing so, we would note that comparative advantages may turn into comparative disadvantages as long as the terms of trade deteriorate over time. This is the so-called "Prebisch-Singer's hypothesis" (see Cypher and Dietz, 1998). The authors assume two kinds of countries involved in international trade: periphery countries (PC) —which export raw materials and import manufactured goods— and core countries (CC) —which export manufactures and import raw materials—. Whether we assume either that there is only one period or that international relative prices remain constant over time, both PC and CC would benefit from international trade. However, the results will significantly change if (1) the model is dynamic or multi-period and (2) PC experiences a deterioration in its terms of trade [2].

The deterioration in the terms of trade reduces the PC's purchasing power. A necessary condition for the existence of comparative advantages is that the terms of trade lie on an intermediate value between the PC's relative prices and the CC's relative prices. Let us suppose that the PC's relative prices are lower than the CC's prices. If the terms of trade fall between these two values, then international trade would provide advantages for both countries. However, if the terms of trade decline over time, then the PC's benefits will be increasingly smaller. Moreover, as long as such a tendency continues to hold, there will be a point at which gains derived from trading with CC turn into losses. When that happens, it will be reasonable for the PC to end up applying an import substitution industrialization policy (Prebisch, 1950).

3. Economic phenomena and the logic of possibility trees

The previous section illustrates the idea that there exist economic mechanisms that, far from being factors that work universally or under a wide variety of conditions, they refer to causal contributions whose manifestation in the real world depends on a set of conditions that must be met beforehand. This is so that any change in these conditions will cause a deviation in the expected result: if the assumption of non-mobility of factors between countries is removed, or if the quantity theory of money is replaced by Marx's theory of money, or if the terms of trade deteriorate over time, then the mechanism of comparative advantages will not take place. And what is worse, the benefit of one country may be to the detriment of the other.

If we had to outline the previous situation, we would hardly appeal to a mechanistic diagram, since what we observe is a path that, depending on what conditions prevail, it branches out to different

sides. Therefore, a better way of schematizing this situation could be through the use of possibility-tree diagrams.

Usually, a possibility tree is a diagram that shows possible alternatives with their respective probabilities once some initial factor is triggered. In our case, the notion of "possibility tree" is not (necessarily) associated with probabilities or some probability theory. Instead, it only means that there exists a multiplicity of courses of action or alternative paths that can be followed —in terms of possibility— after activating a particular causal factor. Let **X** be the causal factor that is triggered and let **Y** be what is followed from **X**. The notion of possibility tree means that **Y** is equal to a set of possible events Y_a, Y_b,..., Y_n, where any of them can be continued once **X** has been triggered. For example, by increasing money supply, the possible effects are an increase in the demand for bonds, or an increase in the price level, or a greater hoarding. When running after an animal, there is the chance that it runs, although it is also possible that it decides to attack us or stay paralyzed. By leaving the state of autarky, a nation can be benefited or damaged. It all depends on what factors come into play at a particular moment and how they end up interacting.

A possibility tree can be a useful tool for recognizing that, in some occasions, there is no "univocal" relationship between variables, entities or values beforehand. More precisely, if the relationship between X and Y were univocal, then we would be able to say that "ceteris paribus, whenever X_1 is properly triggered, Y_1 will occur", where X_1 and Y_1 are specific values for X and Y, respectively, and where it is assumed that this causal relationship is working under isolation, so no other causal factors can perturb the relation between X and Y (see for example Cartwright 1995, 2009; Mäki, 1992, 2009a).

Nevertheless, it is not the case for the international economic models mentioned above (and for many economic models as well). The logic of a possibility tree means that "ceteris paribus, once X_1 is properly triggered, *may* it occur Y_1, Y_2 or Y_n".

Let us start with the notion of ceteris paribus clause (CPC). Although the CPC has a plurality of meanings, in economics it is usually used to leave constant a bunch of independent variables, in order to only focus on the pure relationship between the dependent variable and one of the independent variables. For example, we could define a very simple equation of the type

$$Y = X + Z + W$$

where Y is the dependent variable, and where X, Z, and W are the independent variables. In order to facilitate the analysis, we could assume that there is a genuine causal relationship between the independent variable and the dependent variables, and that the independent variables do not have any type of causal link with each other. We could then set a CPC that nullifies the causal contributions of Z and W, so as to observe the pure relationship between Y and X.

That said, the idea of possibility tree means that the relationship between X and Y is not univocal, but potentially multiple. In other words, for the same value of X, Y may take more than one value. Such multiplicity of possible results depends, among other things, on the activities people carry out and on the underlying structure of the target system.

Broadly speaking, people's actions depend on how they interpret the world's signals, on what expectations they form from such interpretations, on what preferences they have, etc. For instance, in the NMIT agents can increase their preference for good x, and this change in preferences can occur because of a myriad of causes (a higher utility provided by good x, frustrated expectations of some substitute goods, new advertisements, etc.). The change in the curvature of the indifference curve will alter the level of relative prices of optimization, and therefore the exchange relations with other countries. What is more, if this change in preferences and relative prices is sufficiently large, it is plausible that this ends up causing a modification in the country's specialization.

People receive signals or information from the world, and such information is the basis for forming expectations about the future value of certain variables. However, neither the expectations about the future nor the preferences for certain goods are identical for every individual, or even for the same individual in different periods of time. A sharp drop in share prices may cause fear in some brokers, although it may be an opportunity for other brokers to buy them at a lower price. The consequence of the fact that people do not interpret the signals or form their expectations in the same way is that we end up having several possible values for the same initial value, that is to say, several possible paths for a same triggering factor.

Now, people's activities are not especially relevant in the international economic models mentioned above. On the contrary, the multiplicity of possible results substantially depends on the underlying structure of the target system. In socioeconomic systems there coexist a myriad of background conditions (*e.g.*, institutions, nominal and real values from micro and macroeconomic variables, social and cultural norms, etc.). Some of them favor the emergence of economic regularities. Cartwright (1995, 1999) asserts that many of such regularities exist because there is a nomological machine that supports them, where a nomological machine is "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behavior that we represent in our scientific laws" (Cartwright, 1999, p. 50). Nevertheless, there also exist factors that can perturb the nomological machine's good functioning. When this occurs, the economic regularity that emerges from the nomological machine's repeated operation will break off. Cartwright and Efstathiou (2011) call this issue the problem of "unstable enablers". The notion of "unstable enablers" is related to the fact that a causal factor's contribution may be perturbed by changes in the background conditions. In this regard, the comparative advantages mechanism may be understood as a nomological machine that works according to a structure in which the terms of trade do not deteriorate over time, there are no mobility factors among countries, the countries' relative prices are different, etc. However, any change in its underlying structure will break the comparative advantages mechanism. This is analogous to say that the causal path that was taking place —and manifested as a regularity at the level of events— will change to another branch of the possibility.

4. Closing the possibility tree. The role of model assumptions

The models of international trade mentioned in section 2 provide different results because of a simple reason: their underlying structures are different. While the NMIT disregards the significance of the TOT over time, it turns out to be key for Prebisch's model. While the NMIT assumes no capital mobility between countries, Emmanuel shows that, by assuming such mobility, a process of foreign direct investment can be addressed towards the peripheral country, which, under the logic of this model, will end up harming the home country, and so on.

We could think of these models as blueprints of nomological machines that give us information about the laws that are to emerge if certain conditions are met in the real world. More precisely, the assumptions of each of these models can be interpreted as conditions that must be met in the real world, in order to assemble the corresponding machine or mechanism for its right functioning. Under this interpretation, the model assumptions that allow such assembly would be nothing other than statements that fulfill the role of closing the alternative paths of a possibility tree. These closings are necessary so that an economic process or phenomenon is not diverted or interrupted, but targeted to a specific result.

Let us take a look at this in a little more detail. Under the logic of possibility trees, once X is activated, Y_a, Y_b,..., Y_n can occur. For a specific phenomenon (*e.g.*, Y_a) to follow from X, a set of additional conditions "C" must be met. Suppose that X represents the opening of a country to international trade, Y_a the benefits derived from such opening, and Y_b the respective losses. If a set of conditions C is fulfilled beforehand, then Y_a will be reached. In contrast, if the conditions C are not met (and in contrast the set C* is met), then what will be obtained is Y_b, that is:

$(X \,.\, C) \rightarrow Y_a$

$(X \,.\, C^*) \rightarrow Y_b$

where "." and "→" represent the logical connectors "conjunction" and "conditional", respectively. It is quite important to know the content of the sets of conditions C and C*, since they are the ones which specify the path that an economic process is to follow. For example, one could propose the following sets:

Set C:

- The relative prices of autarchy are different from international prices.
- A country specializes in the relatively cheaper commodity.
- There is mobility factors within countries but not across them.
- There is a perfect competition market.
- The quantity theory of money prevails.
- TOT are constant (or favorable).

Set C*:

- The relative prices of autarchy are different from international prices.
- A country specialize in the relatively cheaper commodity.
- There is mobility factors within countries but not across them.

- There is a perfect competition market.
- The quantity theory of money prevails.
- TOT are unfavorable.

Let us note that the only difference between C and C* is the evolution of the TOT. However, this is enough for a country to begin to experience losses in the medium term.

Now, although it is true that both models explain what happens when a country leaves autarky and joins world trade, the assertions in one case and the other belong to different perspectives, which means that, as a consequence, the inferred results will also be different. Thus, it would be wrong to think that the claims of each of these models are universal.

This idea complements Rodrik's claim that models are contingent as they depend on very specific conditions. Rodrik (2015) suggests that the diversity of models in economics improves its explanatory capacities. No model can explain everything. Rather, each model is contingent, that is to say, it depends "on the specific postulated conditions" (p. 25). However, Rodrik does not provide a philosophical account about how this improvement works. In this sense, the present paper is an attempt to complement Rodrik's hypothesis, by claiming that what makes a model to be contingent and not universal is the multiplicity of possible causal paths an economic phenomenon can take place. Let us take once again the NMIT. According to Rodrik, it is just *a* model among several possible models, and it should be complemented with other models in order to provide a better explanation of a phenomenon. In the terminology of possibility trees, on the other hand, it can be said that the behavior that emerges from the working of the NMIT is a *possible* path or behavior among many other alternative paths of a possibility tree, and this is due to the fact that these paths depend, among other things, on people's activities and background conditions, which make causal relationships to be fragile.

If this is correct, then for every real-world scenario there would be a model which provides information about the conditions that need to be met for the purpose of achieving a result. We would not say, for example, that the NMIT is false and Shaik's model or Emmanuel's model are true, nor vice versa. Each of these models is a possible causal contribution that may emerge in case certain conditions are met. They are one expression of a path in a possibility tree. It all depends on the context or on these models' domains. It may be the case that, due to discrepancies in the terms of trade, the advantage comparatives mechanism works correctly in the USA but not in Argentina. However, we should not reject the advantage comparatives hypotheses for its apparent falsehood in the latter case. On the contrary, what we could say is that the conditions for the proper working of the advantage comparatives mechanism were not met in Argentina in that period of time. However, it does not imply that in some other period those conditions may be met.

As can be seen, the assumptions of economic models are key, since they are the ones that show the domain or path of a possibility tree. Nevertheless, not all model assumptions fulfill the same role. For example, it would be absurd for the assumption of indifference curves differentiable at every point to be taken as a condition to be fulfilled in a target system. Since in most of the economic

models their results are obtained via a prior chain of deductive reasoning, it is plausible that many model assumptions just fulfill the heuristic role of simplifying or facilitating such reasoning.

At this juncture, Kuorikoski and Lehtinen (2009), along with several other scholars (*e.g.*, Coddington, 1979; Musgrave, 1981) have examined different kinds of assumptions according to the role they play in economic models. They basically distinguish between *substantive* and *auxiliary* assumptions. Substantive assumptions concern aspects of the model's central causal mechanism about which one endeavors to make important assertions. They are assumptions that have some degree of empirical merit, *i.e.*, they are thought to be more or less true of the systems on which it is hoped that the model will shed some light. Auxiliary assumptions, on the other hand, play a heuristic or tractability role. They are required for making feasible the inferences from substantive assumptions to conclusions.

For instance, when in the NMIT it is asserted that there are only two countries or only two goods, it is clear that they are introduced with the sole purpose of gaining tractability; nobody would expect to find a world where only two goods and only two countries exist. Quite the contrary, what is expected is that the number of countries or goods does not affect the final result. In fact, alternative models such as those of Emmanuel, Shaikh or Prebisch's also assume two countries and two goods. They only fulfill a tractability role in the model; that is why we may think of them as auxiliary assumptions.

Nevertheless, there are other assumptions that, as Kuorikoski and Lehtinen assert, meet a substantive role in economic modeling. Let us take for example the assumption of diminishing TOT over time, or the prevalence of quantity theory of money, or mobility of factors among countries. If they are replaced by other assumptions, then the path in a possibility tree will change.

In this regard, we could say that different models have, most of the time, different substantive assumptions. Therefore, they end up referring to different scenarios or different nodes of a possibility tree. It is not that models are necessarily true or false, but that they have different ranges of applicability. There still remains a question about the association between models and the real world. This question will try to be answered in the next section, where an account of similarity will be incorporated.

5. Similarity

When studying the transformation of international trade in different countries, it is interesting to see how it can be explained more easily by appealing to different models than by sticking to just one. Take the case of Argentina. Towards the end of the 19th century, a type of economic organization associated with the massive use of territorial platforms to develop the exploitation of raw materials from agriculture and cattle raising began to develop in Argentina. This kind of socioeconomic arrangement —called "agro-export model" — had, as its main purpose, the export of these raw materials to more developed countries, which exported their manufactures to Argentina. The Ricardian mechanism of comparative advantage worked perfectly. For Argentina, the relative cost of

producing raw materials was substantially lower than that of producing manufactures. Certain conditions such as the high availability of land, the low level of both physical and human capital, and the international demand for food, had greatly favored this relative cost structure.

However, this glorious model would begin its debacle between 1930 and 1945. The international financial crisis, and later the Second World War, along with internal political and social movements, called into question the idea of continuing a model based on the specialization of raw materials. On the one hand, the Marshall Plan gave priority to the trade of US raw materials to Europe, which displaced part of the Argentine production. On the other hand, the terms of trade showed a constant downward trend. Prebisch (1950) and Singer (1950) were the first economists to put this problem on the agenda which, as shown above, eliminated in the long term the benefits derived from the Ricardian mechanism. Thus, models based on this mechanism —such as the NMIT or the Heckscher-Ohlin model— were not useful for explaining this current reality. A different model, capable of explaining the causes and consequences of this secular deterioration in the terms of trade, was required.

More recently, during 2017, Argentina, which had historically been characterized as a meat-exporting country, began importing beef from Brazil. The reason is simple: the price of Brazilian beef was cheaper than the Argentinean one. Something similar happened with the pork from the US or the wheat from Uruguay. In general, during that period of time, the prices of Argentine products were much higher than those of the rest of the world. As a consequence, imports rose and exports fell, causing a large trade deficit. However, instead of the price correction mechanism proposed by Ricardo, what ended up occurring was a strong indebtedness and a substantial increase in the interest rate. These characteristics are more in line with the Shaikh model than those that take the mechanism of comparative advantages as a cornerstone.

These examples allow us to get an idea that, rather than looking for the "true" model, what we have is a menu of different models. While some of them are more applicable to one context, other models will be more appropriate to others. In some cases, the Ricardian principle is useful for explaining the pattern of trade of a country; in others, it needs to be complemented with other factors; and in other situations, it is not even applicable because certain conditions, such as perfect competition or non-deterioration of TOT, are not met. If we accept that, then the discussion about the relation between economic models and the way they provide information about the real world should not be necessarily related to a matter of verisimilitude or truthfulness, but to their chance of being applicable to different real-world scenarios. In this sense, in this section it is argued that the level of *similarity* between models and the selected part of the world from which it is expected to learn something is crucial, since it is this similarity what will allow agents to select from a menu of models those which best fulfill a scientific purpose (prediction, explanation, representation, etc.).

In order to be more formal, let $\boldsymbol{A}$ be an agent that uses a model $\boldsymbol{M}$ to learn something about a selected part of the world or target system $\boldsymbol{T}$. This means that $\boldsymbol{A}$ does not learn by directly examining $\boldsymbol{T}$, but indirectly by examining $\boldsymbol{M}$. For this to happen, Mäki (2009a) says that some degree of resemblance between $\boldsymbol{M}$ and $\boldsymbol{T}$ must be achieved. The issue is that there is a menu of possible models for $\boldsymbol{T}$. Which of them should $\boldsymbol{A}$ choose?

One option is to rely on the predictive and/or explanatory capacity of models (see, for example, Friedman, 1953). Let us suppose two models $\boldsymbol{M_1}$ and $\boldsymbol{M_2}$ which are expected to account for a target system $\boldsymbol{T}$. According to this premise, $\boldsymbol{A}$ would choose the model that provides the most accurate predictions, that is, that model whose implications are closer to reality than the other model. However, a model providing the most accurate predictions only gives us information about facts that have happened in the past, so we have no basis to expect that such facts will continue to hold in the future. This situation is associated not only with the typical epistemic problem of making inductive inferences, but also with the idea of possibility trees. In other words, it is possible that a model $\boldsymbol{M_1}$ has provided better predictions than $\boldsymbol{M_2}$. But this is not because $\boldsymbol{M_1}$ is necessarily "better" than $\boldsymbol{M_2}$, but because its range of applicability has been more consistent with what has hitherto happened in the real world up to that moment.

This leads us to the second option: not choosing models according to their accuracy regarding past information, but rather to their *similarity* with the selected part of the world from which it is expected to learn something. This similarity is to be understood in comparative terms with respect to the structures that underlie both $\mathbf{T}$ and the menu of models. Following Weisberg (2013), a model $\boldsymbol{M}$ and a target $\boldsymbol{T}$ are *similar* when the features that describe them have close values or when the attributes they share are greater than the attributes they do not share. The smaller the distance between these values (or the greater the difference between the shared and not-shared attributes), the greater the similarity.

Then let $\boldsymbol{E_{mi}}$ be the structure of a model $\boldsymbol{M_i}$. According to what has been asserted in the present paper, each $\boldsymbol{E_{mi}}$ is not arranged by the whole set of assumptions of each model $\boldsymbol{M_i}$, but only by its substantive assumptions. Hence, let $\boldsymbol{E_{mi}}$ be a set such that $\boldsymbol{E_{mi}} = \{B_1, B_2, ..., B_l\}$, where each of the $\mathbf{B}$-tuples is a substantive assumption of model $\boldsymbol{i}$.

Likewise, let $\mathbf{C} = \{M_1, M_2, ..., M_n\}$ be a set of economic models, and let $\mathbf{E} = \{E_1, E_2, ..., E_n\}$ be the set of structures that underlies each of the models. The task of $\mathbf{A}$ is to find the model $\mathbf{M^*}$ that "maximizes" the similarity with respect to $\mathbf{T}$. To carry out this task, $\mathbf{A}$ is to appeal to the several models in $\mathbf{C}$ and compare them to the target system T.

In this sense, Weisberg (2013) asserts that the similarity between two objects depends both on the features they share and on the features they do not share. If we understand structure $\boldsymbol{E_{mi}}$ as the set of features of a model $\boldsymbol{M_i}$, and the structure $\boldsymbol{E_t}$ as the set of features of the target system $\boldsymbol{T}$, then the similarity between $\boldsymbol{M_i}$ and $\boldsymbol{T}$ will depend on how close the values of their features are. Weisberg also argues that the selection of features and their relative importance are contextual-dependent. In other words, $\boldsymbol{A}$ ponders subjectively both shared and non-shared features. Therefore, the similarity between a model $\boldsymbol{M_i}$ and a target system $\boldsymbol{T}$ can be expressed by the following equation (see Weisberg 2013, p. 144):

$$S_i\ (M_i,\ T) = \vartheta f(E_{mi} \cap E_t) - \alpha f(E_{mi} - E_t) - \beta f(E_t - E_{mi}) \qquad (1)$$

where $S_i\ (M_i,\ T)$ represents the value of similarity of a model M_i regarding the target T, $f(\cdot)$ is a weighting function, and α, β and ϑ are term weights. Equation (1) means that the similarity of Mi to T is a function of the features they share ($\vartheta f(E_{mi} \cap E_t)$), penalized by the features that they do not share ($\alpha f(E_{mi} - E_t)$ and $\beta f(E_t - E_{mi})$).

The goal of ***A*** consists in maximizing the similarity between some $\boldsymbol{M_i}$ and ***T***. To do so, let **H** be a set by which its elements are all the values of similarity given by each of the functions (1), that is, $H = \{S_1, S_2, ..., S_n\}$, where the S-tuple represents the value of similarity of each model with respect to the target T. Also, let ***g*** be a function that selects the element of ***H*** with maximum value. Function ***g*** will provide us the model which similarity to the target system T is maximum, that is

$$M^* = g(S_1,..., S_n) \qquad (2)$$

From this perspective, it is not appropriate to talk about *the* model that always maximizes its similarity with the target system. On the contrary, what we have is a menu of models, and depending on the target and on the modelers' purposes, different models will be chosen as the optimal.

On the one hand, technical progress, social policies, environmental changes and many other factors turn the real world into a constantly changing system. This makes the target system to change over time. The immediate consequence of that is that the similarity values referring to different models also undergo modifications. For example, in an open economy where the terms of trade are favorable, where prices act as a regulatory mechanism, and where the market tends towards free competition, it is very likely that the NMIT (or some other model that involves the hypothesis of comparative advantages) yields higher levels of similarity than more heterodox models like Shaikh's or Emmanuel's. But if the scenario involves indebtment, trade deficit or deterioration in the terms of trade, then it is very likely that these models provide higher levels of similarity than the comparative advantages-based models. The example of Argentina illustrates this situation. Argentina has gone through different economic structures, and each of these structures can be better explained if we use different models than if we force one of them to act as a general theory.

On the other hand, it is also plausible that, for different purposes, ***A*** uses different weighting functions. And according to equation (1), different weighting functions means different similarity values. Let us take for example the well-known Schelling model. A chess board with tokens scattered across its squares can be a completely imprecise model, or it can maximize the similarity with respect to a particular city. It all depends on what ***A*** expects to represent. If ***A*** wants to show how ghettos are formed in a dynamical way, it is likely that the level of similarity is sufficiently high. But it is not going to be so if ***A*** wants to explain how specific segregation has occurred in a particular city, where there are both cultural and institutional factors that come into play.

On the use of models

Regardless of whether models are conceived as fictions, metaphors, representations of isolated mechanisms and so on, nobody would doubt that, when building such models, economists intend to say something about the real world. The issue is that (1) what economic models say about the real world is not only approximate but also about a selected part of it, and (2) those who use these models can make undue extrapolations.

Let us examine these two points. (1) refers to what is asserted in relation to a particular target, which can be more or less broad in its domain. This should not be a source of criticism. Properly speaking, any researcher has the right to investigate any aspect of reality, no matter how small or narrow it may be. In such a case, however, it is likely that the similarity with different target systems is quite small. For example, when investigating patterns of international trade between countries, agents can address their research to different targets, *e.g.*, how the trade between the countries of the European Union is, how the TOT have evolved in developed and underdeveloped countries in the last years, how the composition of the capital and labor of Argentinean exportable goods is, etc. These targets may share certain characteristics, *e.g.*, mobility factors among countries (nowadays capital and labor movements occur in almost all countries). In this juncture, an international economic model that assumes zero factor mobility between countries would have, *ceteris paribus*, a lower degree of similarity than a model that does assume factor mobility. However, it does not mean that the similarity values of these kinds of models will always be low. It all depends on which selected part of the real world is expected to be examined and what the purposes of the models' users are.

Likewise, (2) refers not to the models themselves, but to the users of models, specifically, under what circumstances they end up extrapolating the models' contributions to different domains of reality. This idea is in line with Pfleiderer (2018), who warns about the chance of using models that try to bypass the relevant filters, that is, to use them in domains that exceed their range of applicability. In one of his criticisms, he examines a paper whose central thesis is a defense of leveraging in banks. Pfleiderer shows that, leaving aside many aspects of reality, leverage is optimal *as long as* the assets of a bank are riskless (or 100% funded by deposits). However, despite not saying anything about what could happen if the circumstances were different, the work makes claims about the benefits of leverage *even* when the risk is present. This model does not tell us anything about what would happen *if* the assets of banks were risky, so agents who use this model under these new circumstances are likely to fail in representing, explaining or predicting the phenomenon under analysis.

As can be seen, the problem is not related to the (however small) contribution of the model, but to the "undue" extrapolations of its contributions —which, as a matter of fact, are carried out by the agents. A model can say something very narrow about the real world. But it still says something. For example, if a model assumes scenarios that hardly occur in modern reality, then it would have a minimal applicability, and its similarity with the targets under study would be very low. Even so, it can propose some scenarios that, under very specific circumstances, are of interest to the investigative activity (such as, for example, assuming that banks are 100% funded by deposits). In this and many other cases, a similarity analysis is necessary to be carried out.

Final remarks

In the present paper, the idea that the economic mechanisms represented through different models refer not to universal entities but to potential contributions or paths has been defended. In particular, the concept of "possibility tree" —*i.e.*, the description of a set of events that can take place once a causal factor is activated— has been proposed.

As a scheme of a possible path, an economic model only tells us what would happen if certain conditions were met. These conditions —which in the present work have been associated with the so-called "substantive" or "domain" assumptions— turns out to be of vital importance, since if they do not take place in the target system, the model under analysis will lack relevance.

Finally, it has been argued that, for the comparison between a model and its target to be adequate, a similarity analysis is necessary to be carried out. In such analysis, it has been shown that a model can be more or less similar to a target system. It all depends on which selected part of the world is to be examined, what the modelers' purposes are, etc. In this regard, finding the model that "maximizes" its similarity to a target system helps us make decisions in relation to that target. Yet it is not telling us anything about its ubiquity or truthfulness. It is not *the* model, but just *a* model.

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[1] According to the quantity theory of money, there is a direct relationship between the quantity of money and prices.

[2] Prebisch (1950) attributes this deterioration to several factors, among which we can mention the amplitude of the economic cycles in the PC, the inelastic demand for primary commodities and the technological changes.

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