Causality and Structure in Piecemeal Macroeconomic Modeling

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1. Introduction

This paper defends the following assertions concerning some basic features of Post-Keynesian macroeconomic models.

1. The assumption of profit maximization under free competition should be preserved as a building block of a theory of distribution regardless of whether the neoclassical theory of distribution is adopted or rejected. This makes it possible to assess two different types of Keynesian macroeconomic model. While it is widely acknowledged that Post-Keynesian models share a distinctive feature of Keynes's General Theory in so far as they admit a short-period equilibrium of the economy with involuntary unemployment (the equilibrating role of the real balance effect being dismissed as empirically unimportant), they are divided into at least two groups that address the long period in different ways. One group, represented by Kaldor, advocates macroeconomic growth models that reject the neoclassical theory of distribution but are characterized by full-employment equilibria. Another, including most of the economists who have developed Sraffa's critique of marginalism, extends Keynes's principle of effective demand to the long period while preserving the notion of unemployment equilibrium.

2. The received causal interpretation of Post-Keynesian models should be reconsidered in the light of the recent resumption of the structural-equation approach and accounts of causality in econometrics and analytical philosophy. According to a common interpretation of the Post-Keynesian as opposed to neoclassical and new classical models, the arrow of causality goes from investments to savings and

(although this characterization is not accepted by all Post-Keynesians) from the price level to an endogenous money supply instead of the other way round.

3. Piecemeal macroeconomic modeling is better able than a general equilibrium approach to take into account the existence of a non-uniform structure of an economic system. This assertion concerns another division within the Post Keynesian economists: one group (the majority) maintains, or at least does not question, the method of general equilibrium theory expressed by a comprehensive system of algebraic equations; another seeks to break that system down into subsystems endowed with different structural characteristics.

The overviews of theories of distribution put forward by Sen (1963) and Foley-Michl (1999) are taken as points of reference in the following discussion, the former for the short period and the latter for the long period and growth.

2. A taxonomy of macroeconomic models

Let us start from the overdetermination approach adopted by Sen (1963) to construct a taxonomy of theories of distribution. The equations of the overdetermined macroeconomic model are as follows:

(a) the production function: $X = F(N,K)$
(b) labor marginal productivity = wage rate: $PF_N = W$
(c) output value = total income: $PX = rK + WN$
(d) investment = total savings: $PI = S$
(e) the saving function: $S = s_k rK + s_w WN$
(f) given investment: $I = \underline{I}$
(g) full employment: $N = \underline{N}$
(h) full capital utilization: $K = \underline{K}$

where

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X : output	P : nominal output price	s_k , s_w : saving ratios out of profits and wages respectively
N : employment	W : nominal wage rate	I : total real investment
K : real capital	r : nominal rental on capital	S : total nominal savings

The model is overdetermined because eight independent equations constrain seven unknowns: *X, N, K, I, S, W/P, r/P*. Let us call (a)–(h) "model O". Sen's line of reasoning develops in three steps: 1) model O is taken as the starting point; 2) consistent alternative theories are derived by dropping appropriate equations; 3) a causal interpretation of each theory is formulated on the basis of the distinction between exogenous and endogenous variables. Sen derives three main alternative theories of distribution – Neoclassical, strictly Keynesian and Neo-Keynesian – to which Rattsø (1982) adds a fourth attributed to Leif Johansen:

Neoclassical theory	Keynesian theory	Neo-Keynesian theory (Kaldor)	Johansen's theory (Rattsø)
Drop (e): autonomous *I*	Drop (f): full employment	Drop (b): wage= marginal product	Add an endogenous government surplus *F* and replace (d) with *I – S = F*

In our view, a more useful alternative to the overdetermination approach[1] would start from an underdetermined or open/incomplete model that can be taken as a common subsystem subject to alternative integrations. The natural candidate for this role is a production system in the ideal case of competitive profit maximization. If we ignore the criticism of the aggregate production function, the equations that form such subsystem in Sen's classification approach are:

(a) the production function: $X = F(N,K)$

(b) labor marginal productivity = wages: $PF_N = W$

(c) output value = total income: $PX = rK + WN$

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Let us call this underdetermined model with the five variables $X, N, K, W/P, r/P$ and the three equations (a), (b), (c) "model U". This can be used as a benchmark to classify theories of distribution. We shall start by isolating the theories that encompass model U from the others and then go on to consider different additional relations that can be combined with model U and create a determinate model.

3. Profit maximization

The Neo-Keynesian theory described by Sen does not satisfy model U, because it violates equation (b), a condition of profit maximization. As regards the short period, the Neoclassical and Keynesian models can instead be consistently obtained by adding the following groups of equations to the common sub-model U.

Neoclassical theory	Keynesian theory
(d) $PI = S$	(d) $PI = S$
(e) $S = s_k rK + s_w WN$	(e) $S = s_k rK + s_w WN$
(g) $N = \underline{N}$	(f) $I = \underline{I}$
(h) $K = \underline{K}$	(h) $K = \underline{K}$

It is interesting to compare two passages taken from Kaldor and Marglin with regard to the formulation of the Neo-Keynesian model for the long period. The former makes this somewhat cryptic remark:

> *We have seen how the various "models "of distribution, the Ricardo-Marxian, the Keynesian and the Kaleckian are related to each other. I am not sure where "marginal productivity" comes in in all this – except that in so far as it has any importance it does through an extreme sensitivity of v [the capital output ratio] to changes in P/Y [the share of profits].* (Kaldor, 1955-56, p. 96)

Marglin makes the following critical observation:

> *Kaldor resolved the overdetermination by dismissing the marginal productivity relationship altogether. But Kaldor's peremptory dismissal derives from the illegitimacy of a production function based on aggregate capital (l956), not from dissatisfaction with the assumption of competitive profit maximization. If the production function and its derivatives are assumed to represent physical relationships, one cannot so easily ignore the implications of profit maximization. Rather, the issue should be faced head on.* (Marglin ,1987. p. 226)

We agree with Marglin. The assumption of profit maximization should be preserved in both the short and the long-period versions of the macroeconomic model regardless of whether the aggregate production function is dismissed. A basic Keynesian growth model for the long period should be consistent both with a profit-maximizing choice of techniques and unemployment equilibria. A Kaldorian model, in which the demand for labor is at least explicitly disconnected from profit maximization, instead appears to accommodate a full employment equilibrium by relying on some alternative employment function, perhaps of an empirical nature.

4. A preliminary look at causality

Difficult analytical-philosophic questions have to be answered or circumvented by resorting to some primitive concept if a causal interpretation is to be established of a macroeconomic model in general and of its Keynesian features, the saving-investment and price-money relations, in particular. These questions will now be formulated with respect to the savings-investment relation, even though the arguments presented below are general in character and encompass the price-money relation. Let us assume that at least one of the variables *S/P, I* is an <u>ex-ante</u> magnitude, which means that *S/P* and *I* are not identical by definition.

What does it mean to say that *I* causes *S/P*? It obviously means something more than a correlation between *I* and *S/P*. In terms of the present-day philosophical debate, there appear to be two primary candidates for the role of this "something more".

The first, suggested by Hume (1777) alongside his regularity concept of causation and developed by Lewis (1972), hinges on the idea of counterfactual dependence. In "Causation" (1972), Lewis puts forward the idea that a particular (token) event *B* is counterfactually dependent on another particular event *A* if and only if both *A* and *B* occurred and the counterfactual "Had A not occurred, B would not have occurred" is true. Event *C* thus causes event *E* if and only if there is a chain *C*, D_1, D_n, *E* such that each link (except *C*) is counterfactually dependent on the one before it. In our case, the causal relata are variables or type events instead of token events. A basic problem is the selection of the relevant causes out of the host of causes that satisfy Lewis's definition. One way out of this difficulty (regarded by J.S. Mill as insurmountable) would be by setting certain background conditions as distinct from causes.[2] This causation in terms of counterfactual dependence applies to causal models formalized by causal functions,[3] where by convention the variable on the left side of each causal equation is an effect of the variables on the right side and the respective inverse function, if it exists, does not preserve a causal meaning. In our case, *I* causes *S/P* iff there is a chain of variables I, D_1, D_n, *S/P* such that each link in the chain (except *I*) is counterfactually dependent on the one before it. In this case, the background conditions are implicit in the structure of the model. In short, a difference in *I* makes a difference in *S/P*, whereas a difference in *S/P* may not make a difference in *I*.

On the alternative view, shared to differing extents by a heterogeneous group of philosophers and scientists,[4] causation is production associated with processes, mechanisms and causal powers. "*I* causes *S/P*" thus means that *I* produces, brings about or drives *S/P*. This seems to correspond to the common meaning more than the account in terms of counterfactual dependence. It is also in line with the idea of a production process of commodities that is so familiar in economics, in particular a simple labor

process or a process defined as a vector of dated inputs (causes) and outputs (effects). Production becomes the fundamental concept, whereas counterfactual dependence <u>may</u> be a derived property. Despite such appealing features, causality in the sense of production will remain a primitive concept until the black box of the underlying causal mechanism is opened up and explained without falling into a vicious circle by reintroducing the idea of cause.

The two views outlined above are alternatives. A counterfactual account describes a property of an explicit or implicit causal model and the truth of the counterfactual statement is relative to the model chosen. Production is instead a property of the real world. Even if the model is a good description of the world, the accounts of causality based on the two views are distinct and may diverge. Each of them has to face some limited applicability and may clash with common sense. For example, let I_P, I_G denote private and public investments. It is possible to say that I_P produces, brings about or drives S/P, but at the same time S/P does not depend counterfactually on I_P if a difference ΔI_P triggers a difference ΔI_G of opposite sign, through another causal link, and this maintains the same level S/P. By contrast, it is possible to say that S/P depends on I_P, but I_P does not produce S/P if initially $I_P = 0$ and a difference ΔI_P brings about a difference ΔI_G that makes a difference $\Delta(S/P)$. [5]

5. Causality and interventions

A choice must be made here among the theories of causality available in the philosophical literature and mentioned in the previous section. [6] Subject to some philosophical provisos and to recognition of the more fundamental theory based on the concept of production, we shall adopt a <u>manipulationist</u> theory that can be interpreted as a subspecies of the counterfactual account of causality. An excellent overview of this theory, which is accepted by many scientists (but few philosophers), can be found in Woodward (2008). Roughly speaking, causality from a variable X to another variable Y is seen as the existence of a <u>possible manipulation</u> or <u>control</u> of X that makes a difference in Y. Woodward and Pearl

(2000) develop this through similar notions of <u>intervention</u> applied to the variables of causal models. Woodward defines an intervention on variable X with respect to Y under appropriate <u>ceteris paribus</u> assumptions. Pearl (2000) applies a similar but simpler concept to recursive structural models, envisaging a sort of *surgical* intervention that sets the value of X and removes the structural equation where X depends on its parent variables in order to ascertain a counterfactual dependence of Y on X. In formal terms, Pearl introduces the **do(X=x)** operator to represent an intervention that assigns the value x to X and generalizes the previous deterministic definition of causality by adopting a probabilistic theory of causality and Bayesian-network methods of causal inference. His basic idea is that X is a cause of Y iff, for some values x, x', $x \neq x'$, the conditional probability $P(Y = y \mid \mathrm{do}(X = x'))$ is different from the conditional probability $P(Y = y \mid X = x)$, where x is the observed value of X.[7] In short, both Woodward and Pearl combine the notion of intervention with that of counterfactual dependence.

According to the manipulationist approach, "I causes *S/P*" therefore means that there exists some manipulation of *I* through a possible intervention that would change or make a difference in *S/P*.

Attention should be drawn to the following objections raised by some philosophers to this manipulationist theory of causation. 1) The theory does not escape a certain degree of <u>anthropomorphism,</u> as an intervention appears to be related to an agency theory of causation. 2) The theory is vitiated by <u>non-reducibility</u> or <u>circularity</u> because the very notion of intervention is causal. 3) The application of the theory to structural models requires the assumption of <u>modularity</u>.[8] These criticisms will not deter us from adopting the theory for our purposes. First, the contamination of the agency theory of causality and the associated anthropomorphism do not appear so restrictive in the case of macroeconomic models, where human agents act behind the aggregate variables. Second, Woodward (2008) has convincingly defended his approach against the charges of circularity and agency. Third, while the assumption of modularity is certainly a restriction, it can be accepted as a useful simplification in the same way as a basic economic theory was developed by assuming the non-

existence of externalities. Further problems for a causal interpretation of Post-Keynesian macroeconomic models do remain, however.

6. **Additional problems**

A preliminary problem is encountered on attempting to convert a general equilibrium model, taken as a starting point, into a model with an unemployment equilibrium. In general terms, if the price of good j is set in terms of another good, nothing can be found <u>within the model</u> that allows us to drop the equilibrium equation on the j market instead of the market of good k≠j in order to eliminate the overdeterminacy. It is instead necessary to resume the assumption of some causal mechanism, pertaining to disequilibrium analysis and external to the equilibrium model, if a one-to-one correspondence is to be established between a fixed price of a commodity and the equation of its market equilibrium to be removed. This argument applies in particular to the labor market.

More importantly, causality in the macroeconomic models discussed so far cannot be revealed by the distinction between exogenous and endogenous variables and the corresponding closures. The status of exogeneity, without a qualification of the principle underlying the choice between endogenous and exogenous variables (see the distinction drawn by Koopmans in section 7), is not necessary and may not be sufficient for the attribution of a causal role to a certain variable, in particular to the investment *I* in the Keynesian models. This argument raises two related questions. The first is also the title of an article by Hausman (1982) – <u>Are there causal relations among dependent variables?</u> – where the author argues in favor of an affirmative answer. Causal relations can exist among the dependent variables of a complete model if we adopt an account of causality in terms of interventions applied to a causal model. The second is <u>whether an exogenous variable can be non-causal</u>. It should be noted that in a sense, an intervention converts an endogenous variable into an exogenous (<u>exogenized</u>) variable and deletes the corresponding causal function while leaving the rest of the model unchanged. The same

question can therefore be addressed by asking whether the variable is exogenous to the original model or made exogenous by an intervention. It is obvious that a non-causal relation can exist between an exogenous variable X and an endogenous variable Y because of the structure of the model. A different situation arises if the structure of the model admits the possibility of Y being manipulated through a change in X but <u>intervention on X is not possible</u>. The impossibility of intervention is a relative concept. It may be impossible if it violates some law of nature or impossible for human beings. In particular, intervention on X may be impossible if X is defined as a potential instrumental variable in a policy-oriented model.

Let us clarify the problems at issue in the Keynesian model with endogenous investments and a uniform saving ratio s out of total income ($s_k = s_w = s$). Equations (e) and (f) are rewritten as:

$$(e')\quad S = sPX$$

$$(f')\quad I = f(r/P)$$

Let us assume that (e') and (f') are reinterpreted as <u>causal functions</u> describing two distinct causal mechanisms. Let us further assume an intervention such that $I = \underline{I}$ and equation (f') is eliminated without affecting the other equations. "Investments I cause savings S/P" means that manipulation of I through an intervention makes a difference in S/P through changes in income (the theory of the multiplier), and this holds despite the fact that I, S, P are endogenous variables with respect to the complete model. But why not set the real savings and drop equation (e') – instead of (f') – as the result of an alternative intervention on S/P and say that savings "cause" investment through a change in the rate of interest? On the basis of the model, it may be just as legitimate to say that consumption causes both savings and investments, as the model does not preclude an intervention on consumption, which is implicitly defined $C = PX - S$ in Sen's classification. As a matter of fact, the form of the equations and the distinction between endogenous and exogenous variables of the model do not reveal the existence

of a causal relation running from investments to savings instead of the other way round even if $S(.)$, $I(.)$ are interpreted as causal functions. Stressing the causal role of investments within the received Post-Keynesian models can, however, be justified by some external assumption about the existence of possible and impossible policy interventions associated with instrumental variables in Tinbergen's sense. This idea may be in the back of the minds of many Post-Keynesians who are in favor of a causal interpretation of their equilibrium models. They may be thinking of an implicit experimental policy design where investments can be manipulated through public investments but savings cannot be controlled in such a direct way. This is a plausible interpretation, but the form of the model reveals nothing in this sense. Some older distinctions between exogenous and endogenous variables can offer further support for our argument.

7. Useful earlier views on exogeneity

A seminal discussion of the choice between exogenous and endogenous variables in economic models can be found in the early econometric literature during the years just before and after World War II in the circles of the Cowles Commission and until the mid-1960s. After decades of comparative acquiescence, the question has recently been taken up by some econometricians (Hoover 2001) engaged in a discussion with analytical philosophers on causality and causal models. Pure economists too often appear to be satisfied with a purely logical distinction between the variables of a model (endogenous, i.e. determined by the model itself, and exogenous, i.e. determined outside it) and with what Koopmans called the departmental principle (see below). We instead believe that economists can benefit from both earlier and more recent contributions, especially for the assessment of the choice of alternative closures and corresponding choices of exogenous and endogenous variables.

Koopmans (1950) observed that three different principles have been implicitly or explicitly applied in determining which variables are exogenous in the economic literature, namely the

departmental principle, the causal principle and the purpose of exposition (which is mentioned only in passing).

> The *departmental principle treats as exogenous those variables which are wholly or partly outside the scope of economics, like weather and climate, earthquakes, population, technological change, political events. The causal principle, which does not always lead to the same result, regards as exogenous those variables which influence the remaining (endogenous) variables but are not influenced thereby.* […] *Third principle or consideration: the purpose of exposition. At a certain stage of the analysis, variables are often treated as exogenous to facilitate understanding of the model studied, reserving for later elaboration their inclusion among the endogenous variables* […]. (Koopmans, 1950, pp. 393–5)

Koopmans argues that only the causal principle can be relevant for the choice of the exogenous variables from a statistical-econometric point of view, in particular with reference to the maximum-likelihood method of estimation. It is in fact clear that the departmental principle is of little use to an econometrician who has no reason to defer to a conventional definition of economics. The "purpose of exposition" instead requires further discussion, as it appears to be related to or overlap with a fourth principle, namely the principle of open or incomplete models. This point is discussed at greater length below.

Simon and Rescher (1966) add a further interpretation of the exogenous variables of static equilibrium models from a dynamic perspective. Assume that a dynamic system is described in canonical form and the variables observed over a period are divided into three classes:

1. *Variables that have changed so slowly that they can be replaced by constants for the period under observation, deleting the corresponding mechanisms from the system.*

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2. Variables that have adjusted so promptly that they are always close to (partial) equilibrium, hence their first derivatives always close to zero. […]

3. All other variables. (Simon and Rescher, 1966 pp. 334–5)

This suggests that a static equilibrium model approximates a dynamic system over a period by assuming that variables of type 1 are exogenous. We shall leave aside some new concepts of exogeneity adopted in econometrics (e.g. super-exogeneity) and focus instead on some important contributions of early econometricians related to the problem considered here.

8. Causal relations and general laws

Haavelmo (1944) stresses the need to specify some hypothetical-potential <u>experimental design</u> in order to attribute empirical content to general models. Only then can the relations among the variables of the model be interpreted as causal relations. In particular, some general economic "laws" are not causal <u>per se</u> in the same way as most general laws in physics. Let us illustrate this analogy by reference to two physical laws and two economic laws.

1. Ohm's Law states that $I = \dfrac{V}{R}$, where I is the current intensity (measured e.g. in amperes), V the potential difference (e.g. in volts), and R a parameter called the resistance, (e.g. in ohms).

2. The ideal gas law states that $PV = NkT$, where P is the absolute pressure of the gas (measured e.g. in atmospheres), V the volume of the gas (e.g. in liters), N the number of molecules in the gas (e.g. in moles), k a constant (called Boltzmann's constant), and T the absolute temperature.

3. Accepted by economists for a long time as a general law of economics, the equation of the quantity theory of money states that $MV = PQ$, where M is the total amount of money, V its velocity of circulation, P the general price level, and Q the total amount of commodities subject

to transactions.

4. A less simple economic example is the price equation $(1+r)\mathbf{A}\mathbf{p} + w\mathbf{l} = \mathbf{B}\mathbf{p}$, where $\mathbf{p}$ is a price vector, r the uniform rate of profits, w the wage rate, and the triple: $\mathbf{A}$ (commodity input matrix), $\mathbf{l}$ (labor input vector), $\mathbf{B}$ (commodity output matrix) the technology in use. Let us compare the four equations:

$$I = \frac{V}{R} \qquad (1)$$

$$PV = NkT \qquad (2)$$

$$MV = PQ, \qquad (3)$$

$$(1+r)\mathbf{A}\mathbf{p} + w\mathbf{l} = \mathbf{B}\mathbf{p} \qquad (4)$$

None of the equations, considered as such and regardless of its form in terms of dependent and independent variables, expresses a causal relation. Each equation is an open model, and dependent and independent variables can be freely chosen in order to analyze the properties of the relations. A causality nexus emerges only if a hypothetical experiment is specified and the model is closed by setting some variable equal to a parameter that can be controlled from outside the model. This entails a causal interpretation of the choice between exogenous and endogenous variables.

In the case of law (1), it is possible to imagine an electric circuit made up of a two-cell battery, a conductor (e.g. a wire of a certain metal, diameter and length), and an ammeter. The battery can be replaced with a one-cell battery, *ceteris paribus*, and the ammeter will measure a 50% decrease in intensity. It is then possible to say that a change in V (exogenous variable) caused a change in I. Alternatively, it is possible to change the metal, diameter or length of the wire. In this case, I would again change and this change would be <u>caused</u> by a change in R (exogenous variable), under *ceteris paribus* assumptions including the battery. Similar considerations apply in the cases of laws (2) and (3).

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It is only on the basis of a hypothetical experiment that a causal relation can be specified among P, V, T in equation (2) or M, V, P, Q in equation (3) subject to a *ceteris paribus* clause. Without a potential experiment, the equations (1), (2) and (3) might at most <u>define</u> a variable in terms of the others or enter accounting identities, but without a causal interpretation. For example, the ratio of the intensity I over the potential V defines the resistance R according to equation (1). The ratio $V \equiv \dfrac{PQ}{M}$ defines the velocity of money circulation in equation (3). On these interpretations, it is possible to extract a pair of variables from each equation that become <u>causally identical even though they are conceptually distinct</u>, as pointed out in Hoover (2011). The case of equation (4) will now be discussed in the next section.

9. The price equation

In addition to the common features of the four laws outlined above, it is important to stress some specific characteristics of the price equation expressed by the law $(1+r)\mathbf{A}p + w\mathbf{l} = \mathbf{B}p$.

1. The price equation represents a general law as regards its <u>form</u>, whereas the values of its parameters can change across time and space. Even the form written above can be interpreted as a special case of a more general law that describes a system of production with land, exhaustible natural resources, taxes and foreign trade.

2. The equation must hold also as accounting relations among <u>ex-post</u> magnitudes of a corresponding economic subsystem observed in a state of long-period competitive equilibrium.

3. In the case of production with only circulating capital, a mathematical solution to equation 4, combined with the choice of an appropriate standard of value (the standard commodity), can be written either $w = \dfrac{R-r}{R}$ or $r = (1-w)R$, where R is the maximum rate of profit that depends on the cost minimizing techniques A*, l*, B*. If the convention is adopted that the caused variable

is written on the left side of each equation, the two expressions, even though they are not structural relations, describe opposite causal relations between w and r.

4. The equation should be interpreted as the result of a cost-minimizing choice of techniques with respect to a set of linear available techniques Aj, $\mathbf{l_j}$, $\mathbf{B_j}$, j = 1.2…n. The corresponding subsystem of price/cost inequalities can be a substitute for the price equation in terms of marginal productivities derived from an aggregate production function in Sen's classification of theories of distribution.

5. The system of price equations $(1+r)\mathbf{A}p + w\mathbf{l} = \mathbf{B}p$ is open and not <u>causal</u>. The absence of causal relations among its variables does not preclude an underlying causal microeconomic model. The equations are consistent with a deterministic model where agents act to maximize their profits and parametric prices "cause" their choices of techniques. Alternatively, they may derive from a process of natural selection or a probabilistic mechanism where a multitude of microstates conform to the laws of thermodynamics and some regularity emerges only at the level of macro states (at the industry level in our case) .

6. The open system (4) can be closed by setting either $w = \underline{w}$ or $r = \underline{r}$, where $\underline{w}$ (in terms of some standard of value) and $\underline{r}$ are respectively parameters potentially under control. Subject to each alternative closure, the top rank of the corresponding closed subsystem might shrink in terms of the criteria a), b), c) with respect to the open system (4). It cannot, however, be said that w, measured in terms of a given standard of value, causally depends on r only because the latter variable is chosen as exogenous. Nor can it be said that r causally depends on w only because their causal role is reversed. In actual fact, the choice of the exogenous variable may correspond to what Koopmans called the purpose of exposition. In this case, if r is chosen as exogenous rather than w, the purpose might simply be the quest for analytical simplicity obtained by dealing with a system of linear rather than non-linear equations.

The price equations will be reconsidered in a separate section because of the key role they can play in modeling an economic system through distinct stages of analysis. A piecemeal theoretical construction, where "piecemeal" is not used in a pejorative sense, is defended by bringing various ideas both old and new together by means of a common thread, namely the recognition of non-uniform structures.

10. **Non-uniform social structures**

A social system is a <u>complex</u> system that is not characterized by a uniform structure in a number of overlapping senses. The system may lack a uniform structure because of a) differences in the *persistency and autonomy* of economic relations in the sense of Frisch and Haavelmo; b) differences among relations in terms of *invariance* and *modularity* in the sense of Woodward and Hausman; c) the existence of *hierarchies* in the sense of Simon. The notions of *causal order*, *decomposability* and *near decomposability*, as introduced by Simon, are properties of systems of equations that represent non-uniform structures within causal models. Let us expand these notions by quoting significant passages from the works of the above authors.

Frisch and Haavelmo strongly emphasize the existence of <u>persistent</u> and <u>autonomous structural</u> relations in the face of the difficulty of exploiting controlled experiments of economic processes and the passive observation to which economists are necessarily confined. Their ideas and general principles are especially useful with a view to characterizing the empirical content of different macroeconomic models and their potential for policy interventions. While <u>persistency</u> is self-explanatory, <u>autonomy</u> requires a more technical definition.[9]

"*A system of autonomous equations is characterized by the property "that it is possible that the parameters in any one of the equations could in fact change* [...] *without any change taking place in any of the parameters of the other equations*" (Frisch, 1948, preface)*.

<u>Modularity</u> has already been defined in section three (footnote 5). As regards invariance:

"The general idea of invariance is this: a generalization describing a relationship between two or more variables is invariant if it would continue to hold—would remain stable or unchanged—as various other conditions change. The set or range of changes over which a relationship or generalization is invariant is its domain of invariance." (Woodward, 2000, p. 205)

The concepts of causal order and decomposability are well-known and their definition is omitted here. *Near decomposability* and *hierarchies* describe non-uniform structures from the viewpoint of the evolutionary dynamics of complex systems. The major innovative idea can be found in Ando-Simon (1961) and its subsequent developments in Iwasaki and Simon (1993) and Simon (1996). Simon is interested in a general characterization of social, biological and physical systems,[10] and his primary results are summarized in the following extract:

"[…] we may move to a theory of <u>nearly decomposable systems,</u> in which the interactions among the subsystems are weak but not negligible. […] At least some kinds of hierarchic systems can be approximated successfully as nearly decomposable systems. The main theoretical findings from the approach can be summed up in two propositions: 1) in a nearly decomposable system the short run behavior of each of the component subsystems is approximately independent of the short-run behavior of the other components; 2) in the long run the behavior of any one of the components depends in only an aggregate way on the behavior of the other components." (Simon, 1996, p. 197)

11. The piecemeal construction of causal macroeconomic theories

A theory of an economic system should acknowledge the existence of non-uniform social structures in the various senses illustrated above, whereas the traditional general equilibrium approach in economics seems to presuppose a uniform structure. If the aim is to describe a capitalist economy ruled by free competition, the production system, represented by a subsystem of equations (the price equations),

should stand as a subsystem with a high degree of autonomy and persistence with respect to the other subsystems that form a hierarchic social system. More importantly, the modeling of each subsystem may require a different analytical approach and expertise in different social sciences in addition to economics and including historical disciplines. This echoes the classical approach and the idea of the "core" of the surplus theory of value and distribution adopted in Garegnani (1984).

"*The surplus theories have, so to speak, a core which is isolated from the rest of the analysis because the wage, the social product and the technical conditions of production appear there as already determined. It is in this "core" that we find the determination of the shares other than wages as a residual: a determination which, as we shall see in the next section, will also entail the determination of the relative prices of commodities. Further, as a natural extension of this, we shall find in the "core" an analysis of the relations between, on the one hand, the real wage, the social product and the technical conditions of production (the independent variables) and, on the other hand, the shares other than wages constituting the surplus, and the relative prices (the dependent variables)*.*" (Garegnani 1984, p. 296)

12. Conclusions

This paper suggests the need for an extension of the classification of growth models presented in Sen (1963) and Foley-Michl (1999) and a critical appraisal of the said models.

First of all, a comprehensive classification should include a classical growth model with long-period unemployment equilibria and profit-maximizing choice of techniques. Furthermore, our cursory inspection of causal models points out a common limitation of the macroeconomic models examined in Sen (1963) and Foley-Michl (1999). Their form, in terms of algebraic functions and equilibrium equations, is not such as to reveal a causal nexus running from investments to savings and the non-

uniform causal structure of a complex economic system. The choice of exogenous variables and the corresponding closures is not sufficient to describe a causal nexus among the variables. Moreover, the simultaneous equations of the general-equilibrium approach cannot cope with the existence of a non-uniform structure of the social system. For this purpose, we need the formulation of causal models and structural equations and piecemeal macroeconomic modeling through a multi-stage analysis of separate subsystems. This appears to be a sound methodological principle. The need remains for theoretical and applied work focused on the interfaces between the separate theoretical subsystems. This is a difficult task because, for example, an economist well-equipped to deal with Sraffa's price equations and their extensions may not be so capable of dealing with phenomena outside that analytical context and involving specific institutional, political, historical and philosophic analyses as well. On this issue, which concerns the prospects for progress in political economy, attention can be drawn to an analogy in the use of words in two different areas of enquiry. Some interpretations have used the term <u>technical progress</u> for the statistical residual measured by the shift of the aggregate production function in the Solow-Denison approach to growth performances. It has been pointed out, however, that the term in this context is just another name for our ignorance. In a sense, the words "institutional factors" in the received Post-Keynesian theory of prices have a similar connotation. In point of fact, economists tell plausible stories to justify, for example, the choice of an exogenous variable chosen from among the rates of profit, accumulation and real wages. Sraffa has suggested that institutional factors affect the rate of profit, for example, and in particular that the central bank can act on this rate through control over the rate of interest. Similarly, Joan Robinson has indicated the "animal spirits" of entrepreneurs as the prime mover of accumulation, and institutional and historical factors have been invoked to justify the choice of an exogenous real wage. While these suggestive terms indicate plausible alternatives to the neoclassical theory of distribution, they are at the same time indicative of an incomplete theory (ignorance would perhaps be too strong an expression) calling for the analysis of other subsystems,

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especially as regards consumers, the behavior of firms, and social norms.

REFERENCES

N. Cartwright (2007), "Causal Powers: What Are They? Why Do We Need Them? What Can Be Done with Them and What Cannot?" Centre for Philosophy of Natural and Social Science Contingency and Dissent in Science. Technical Report 04/07, LSE.

D. Foley and T. Michl (1999), Growth and Distribution, Harvard University Press 1999.

R. Frisch (ed) (1948), Autonomy of Economic Relations, a Collection of Articles Issued by the University of Oslo.

P. Garegnani (1984), "Value and Distribution in the Classical Economists and Marx" Oxford Economic Papers, Vol. 36, No. 2, pp. 291-325.

T. Haavelmo (1944), "The Probability Approach in Econometrics" Econometrica, Vol. 12, Supplement (Jul., 1944), pp. iii-115.

D. Hausman (1982), "Are there Causal Relations among Dependent Variables?". Philosophy of Scienc, 50, pp. 58-81

D. Hausman and J. Woodward (1999), "Independence, lnvariance and the Causal Markov Condition" British Journal of Philosophy of Science. 50, 52l—583.

K. Hoover (2001), <u>Causality in Macroeconomics</u>, Cambridge: Cambridge University Press.

K. Hoover, (2011), "Causal Structure and Hierarchies of Models" Electronic copy available at: http://ssrn.com/abstract=1735588.

D. Hume *[1777], A Treatise of Human Nature*, edited by L. A. Selby-Bigge, 2nd ed. revised by P.H. Nidditch, Oxford: Clarendon Press, 1975.

N. Kaldor (1955-56), "Alternative Theories of Distribution", <u>Review of Economic Studies</u>, 22, pp 83-100.

T. Koopmans (1950), "When Is an Equation System Complete for Statistical Purposes?" in T. Koopmans ed. <u>Statistical Inference in Dynamic Economic Models</u>, Cowles Commission Research, J. Wiley & Sons, New York – London.

D. Lewis (1972), "Causation", <u>Journal of Philosophy</u>, 70, pp. 556-67.

J.L. Mackie (1974). *The Cement of the Universe. A Study of Causation*, Oxford: Oxford University Press.

S. Marglin (1987), <u>Growth, Distribution and Prices</u>, Harvard Economic Studies.

S. Parrinello (1999), "Explaining and Understanding Economic Events by Contrasting Alternatives",

Metroeconomica, 50, 3, pp. 325-350.

L. Pasinetti (1965), "A new theoretical approach to the problems of economic growth", *Pontificia Academiae Scientiarum Scripta Varia*, 28, pp. 571–696. [Reprinted in *The Econometric Approach to Development Planning* (Amsterdam, North Holland, 1965).

J. Pearl (2000). *Causality: Models, Reasoning, and Inference*. Cambridge: Cambridge University Press.

J. Rattsø (1982). "Different Macroclosures of the Original Johansen Model and their Impact on Policy Evaluation", Journal of Policy Modeling, 4(1): pp. 85-97.

B. Russell (1918), "On the Notion of Cause" In *Mysticism and Logic*. London: George Allen & Unwin.

W. Salmon (1984), *Scientific Explanation and the Causal Structure of the World*. Princeton: Princeton University Press.

A. Sen (1963), "Neoclassical and Neo-Keynesian Theories of Distribution", Economic Record 39:53-64.

H. Simon (1953). "Causal Order and Identifiability," in William C. Hood, and Tjalling C.Koopmans, editors, *Studies in Econometric Method*, Cowles Commission Monograph 14. New York: Wiley, 1953, pp. 49-74. Page numbers refer to the reprint in Simon, *Models of Man*. New York: Wiley, 1957, pp. 10-36.

H. Simon and N. Rescher. (1966), "Cause and Counterfactual," *Philosophy of Science* 33(4), 323-340.

Simon, Herbert A. (1996) *The Sciences of the Artificial*, 3rd ed. Cambridge, MA: MIT Press.

J. Woodward (2000), "Explanation and Invariance in the Special Sciences", British Journal of Philosophy of Science, 197-254.

J. Woodward (2003), Making Things Happen, a theory of causal explanation, Oxford University Press.

J. Woodward (2008), "Causation and Manipulability", Stanford Encyclopedia of Philosophy, http://plato.stanford.edu/entries/causation-mani.

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[1] It should be noted that the disaggregated approach of Pasinetti (1965) exhibits a certain similarity with the one adopted in Sen's classification, in that both rest on overdetermined models. While Sen's purpose is to classify the major theories of distribution, Pasinetti appears to be intent on showing that a disaggregated formulation of a growth model of the Harrod type displays greater potential flexibility of the economy – by comparison with its aggregate ancestor – to keep within a path of full employment.

This flexibility, which might be embedded in a variety of different descriptive or normative models left to future research, should obviate what Harrod calls a discrepancy between the <u>natural</u> and the <u>warranted</u> rates of growth.

[2] See Mackie (1974).

[3] The meaning of the word "counterfactual" is similar but not identical in Lewis and in the literature of causal models. In the latter context, it is not really appropriate to call variables counterfactual because all *relata* can be purely hypothetical instead of either factual or counterfactual.

[4] As exemplified by Russell (1918), Salmon (1984) and Cartwright (2007).

[5] The contrast and ambivalence of the two rival accounts of causality are illustrated by the typical counterexamples of <u>pre-emption</u> , <u>late-emption</u> and <u>overdetermination</u> in the philosophical literature.

[6] A discussion of causes as difference-makers related to theories of explanation and understanding can be found in Parrinello (1999).

[7] It should be noted that $P(Y = y \mid X = x)$ may differ from $P(Y = y \mid \mathrm{do}(X = x'))$ even if x = x' because an intervention $\mathrm{do}(X = x')$ converts an endogenous to an exogenous determination of same value of X.

[8] "Modularity involves a stronger invariance condition that also applies between equations. It says that each structural equation in a system of structural equations that correctly captures the causal relations

among a set of variables is invariant under interventions that disrupt other equations in the system by setting the values of their dependent variables within some limited range." Hausman and Woodward, 1999, pp. 542 –3.

[9] This definition is close to the definition of modularity attributed to Pearl and Woodward.

[10] Simon defines "effective" hierarchies among subsystems in social systems: "Almost all societies have elementary units called families, which may be grouped into villages or tribes, and these into larger groupings, and so on. If we make a chart of social interactions, of who talks with whom, the clusters of dense interaction in the chart will identify a rather well-defined hierarchic structure. The grouping may be defined operationally by some measure of frequency of interaction in this socio-metric matrix." Simon, 1996, p. 185.