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Causality and interdependence in Pasinetti's works and in the modern classical approach*

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One of the items that Pasinetti rightfully emphasizes in characterizing the Cambridge school, and differentiating it from mainstream neoclassicism, is causality versus interdependence. (Leijonhufvud, 2008, 537)

Abstract. The formal representation of economic theories normally takes the shape of a model, that is, a system of equations which connect the endogenous variables with the values of the parameters which are taken as given. Sometimes, it is possible to identify one or more equations which are able to determine a subset of endogenous variables priory and independently of the other equations and of the value taken by the remaining variables of the system. The first group of equations and variables are thus said to *causally* determine the remaining variables. In Pasinetti's works, this notion of causality has often been emphasized as a formal property having the burden of conveying a profound economic meaning. In this paper, we will go through those works of Pasinetti where the notion of causality plays a central role, with the purpose of contextualizing it within the econometric debate of the Sixties, enucleate its economic meaning, and show its connections with other fields of the modern classical approach.

Keywords: causality, interdependence, modern classical approach, Ricardo distribution theory, Keynes's analysis, 'given quantities', surplus approach, structural dynamics, vertical integration.

JEL codes: B00, B24, B51, C50, E12.

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1. Introduction

Throughout his career, Luigi L. Pasinetti has worked on the titanic confrontation of two opposing paradigms: the Classical-Keynesian versus the Marginalist or Neoclassical. Among the major differences which mark the distance between the two is, in his view, the importance and role they respectively attach to the principles of causation and interdependence in economic theorizing.

During the 1970s and 1980s a vivid debate arose on the meaning and the significance of the concepts of causality and interdependence in economic theory: those very concepts came to be dissected along many different perspectives and somewhat intermingled, so that the area of disagreement widened without providing grounds for clarifying the different positions (Cavalieri, 1987-1988; Vercelli, 1991). This dispute had clear connections with the ongoing developments in econometrics: the spreading application of VAR and later SVAR techniques revived the discussion between (and within) the supporters of a structural approach to econometrics, grounded on the construction of structural models representing a set of allegedly stable economic behaviors, and the process approach, basically rejecting any a-priori assumption and focusing exclusively on the multiple correlations emerging from historical time-series of economic data (Hoover, 2008, p. 724; Cellini, 1995, p. 343; Drakopoulos and Torrance 1994, p. 186-187)[1]. More generally, the debate over causality in economics and econometrics involved deep epistemic issues concerning the meaning of causality, which recursively resumed a deterministic stance, both in the theoretical and probabilistic analyses (Vercelli, 2001, p. 1; Drakopoulos and Torrance, 1994; Cavalieri, 2000).

Pasinetti's own interest in the notion of causality dates back to his initial studies at the Catholic University of Milan under the tutorship of Francesco Vito and the then young Siro Lombardini. Especially the latter introduced Pasinetti to the study of econometrics and encouraged him to devote his dissertation and his first research papers to the study of consumption and investment functions in econometric models (Pasinetti, 1955, 1957a, 1956). In 1957-58, in the middle of his PhD studies at Cambridge (UK) and Oxford, he spent one year in Harvard, attending Franco Modigliani's courses. In 1964, Pasinetti was appointed professor to the newly created chair of Econometrics at the Catholic University[2].

Yet, since the end of the 1950s, Pasinetti's interest in causal economic relations was driven more by theoretical reflection than empirical verification or econometric modeling. His encounter with the Cambridge school spurred his attention to the different methodological approaches that differentiated the classical and the Keynesian economists from neoclassical ones and from the younger generation of Keynesians (not

[1] On the history of econometrics see Epstein (1987), De Marchi and Gilbert (2001), Morgan (1990), Qui (1993).

[2] On Pasinetti's training as an economist see Parisi (2013), Quadrio Curzio and Rotondi (2004, p.402-405).

yet labeled "bastard") whose growing influence on modern macroeconomics and policy making was couched in the form of a reconciliation of Keynes with Walrasian general equilibrium analysis. Pasinetti's own desire to qualify the differences between those streams of thought, not yet openly fighting each other, led him to specify their different visions of economic theory. In his view, in the classical and in the Keynesian traditions the working of the system is better understood if the relationships among some central economic variables are described in a *causal* rather than in an interdependent form, as if they were acting as a *primum movens* of the phenomenon described. This is the case for the rate of profit in the Ricardian model (1960), the principle of effective demand in the Keynes's General Theory (1974)[3], technology and consumption patterns in his own *Structural change and economic dynamics* (1981; 1993), capitalist's saving decisions in Kaldor's theory of growth and income distribution (1962 and 1974).

Pasinetti's attentiveness to the notion of causality has never waned: the development of a strong notion of causality (and time dependence with it) is still regarded, in his own words, as one of the major challenges economic theorizing should address today in order to recover its own role among the social sciences and help provide answers to the most pressing social issues of our time, such as unemployment, technical change and income distribution.

> The notion of historical time opens up the question of causality. ... There are relations, in economics, that are genuinely interdependent. But there are other important economic relations that are characteristically asymmetrical, as far as the chain of causality is concerned. They should not be artificially forced into a logical frame in which everything depends on everything else, which is tantamount to introducing an unjustified sharp distinction which considers any specific variable as *either* totally unimportant (and in this case to be neglected) *or* of some importance and in this case to be considered exactly on the same level as, and symmetrically to, any one of the other variables, no matter how important these latter variables may be relative to the former (Pasinetti, 2007, p. 226).

In this paper we shall try to trace the origins of Pasinetti's notion of causality (Section 2) and describe how it was developed in his major works. We will especially focus upon his famous reformulation of the Ricardian system (Section 3), his view of Keynes's contribution vs. Hicks' neoclassical synthesis (Section 4), his analysis of structural change (Section 5) and of income distribution along post-Keynesian lines (Section 6). Section 7 concludes.

2. Pasinetti's reflection on causality

Pasinetti's interest in the relationship between causality and interdependence in economics was deeply rooted in his own training as an econometrician under the guide of Siro Lombardini. Since the late 1940s, Lombardini had been an acute observer of the rapid advancements occurring in theoretical economics and in econometrics: a two-

[3] On Keynes's concept of causality see Carabelli (1983) and (1988) and Vercelli (1991).

years fellowship in the United States allowed him to follow the works of the Cowles Commission and acquire broad knowledge of the main technical and methodological issues involved in econometric modeling (Lombardini, 1952, p. 409). In the 1950s Lombardini continued to take part in the conferences of the Econometric Society and assessed the pros and cons of the different positions emerging in the debate (Lombardini, 1955, p. 1957)[4].

Two major approaches faced each other at the time: the Cowles commission's approach, that geared toward the "structural" econometric models, based on the identification of exogenous and endogenous variables, within a system of simultaneous equations; and the minority approach, developed by Herman Wold and the Swedish school, based on "process" analysis, with causal relationships and time dependence as basic features, with no a-priori distinction between endogenous or exogenous variables (Lombardini, 1955, p. 304-309; Hoover, p. 2008: 721).

A third solution was proposed by Herbert Simon in a famous 1953 article on "Causal ordering and identifiability" in which, in the context of structural models, he defined causality as an asymmetric or "recursive" relationship between variables (not necessarily sequential in time), taking care of distinguishing the positivistic, ontological and deterministic notion of causality from a more acceptable logical notion, related to the formal property of a model (Hoover, 2008, p. 721; Lombardini, 1955, p. 309).

It was Lombardini who encouraged Pasinetti to devote his undergraduate dissertation to a deep and detailed discussion of the main econometric models of business cycles elaborated at the time by Jan Timbergen (1939), Colin Clark (1949) and Lawrence Klein (1950), built upon the newly available data on the American economy of the interwar years. An estimation of the consumption and investment functions was also the specific focus of Pasinetti's early articles (1955 and 1957a) in which he made an attempt to improve the former models with the new theories of consumption developed by Franco Modigliani and James Duesenberry.

While in these articles he did not develop Lombardini's criticism of structural economic modeling, he came to express a growing skepticism about the ability of these models to capture economic reality. Beside the unrealistic assumption of linearity (especially when major changes occurred in some exogenous variables) and the problems involved in the inclusion of expectations and qualitative or institutional change, Pasinetti was particularly concerned with the instability (and unreliability) of aggregation:

> aggregate variables cannot take into account the relative variations among the elements of the group which has been aggregated. Furthermore, when passing, without making a distinction, as is frequently the case, from an analysis of the behaviour of the individual economic units to the behaviour of the whole set, an implicit assumption is made of a correspondence, which in reality is not always perfect, between the behaviour of the single individuals and that of the collectivity. In particular, such a correspondence is not possible

[4] On the development of econometrics in Italy and its impact on policy making see Rey (2004); Lavista (2010).

> when the decisions of the single economic entities are not independent of each other (Pasinetti, 1956, p. 149, our translation).

Pasinetti's growing dissatisfaction with structural econometric models was of a deep theoretical nature. The aggregation of many different economic processes could encroach the autonomy and reliability of the structural relations as emerging from empirical observation. A methodological refoundation of economic inquiry was implicitly invoked by the young Italian economist:

> Entirely different is the meaning of the relations based upon profound theoretical formulations which, as oriented to identify the more remote causes that determine the phenomena considered, propose to explain both the observable results and the results that could have been obtained under different conditions, ... Thus, it is in the direction of new formulations in the field of economics that we envisage the major contributions for building and developing econometric models (Pasinetti, 1957a, p. 62, our translation).

It is to be noticed that, at the time, Pasinetti was as a graduate student, under the powerful intellectual influence of the Cambridge (UK) school. In 1957 he attended Kaldor's courses on growth and income distribution and read Joan Robinson's *The Accumulation of Capital* (1956). A clear testimony to the rapid transformation in his way of reasoning is offered by a brief note, presented in a Conference organized by the CISL trade-union, in which Pasinetti, in a style very similar to Harrod's and Robinson's dynamics, developed a simple model of a dual economy with productivity differentials and different stages of economic developments, where a repression of wages in the core economy led to a relative stagnation of aggregate demand, inadequate innovation, and lower capital accumulation with structural unemployment (Pasinetti, 1957b). In the following years, during his PhD training in Cambridge, Pasinetti completely abandoned his original and appreciated research efforts in econometric modeling and devoted himself to economic theory along the lines drawn by Kaldor, Robinson and Sraffa. As we shall see in the next sections, his major works of the 1960s, on the relationships between growth, full employment and income distribution, were all grounded on a strong notion of causality.

The first occasions in which Pasinetti had the opportunity to clarify his concept of causality was in 1964 at his inaugural lecture for the Econometrics course at the Catholic University of Milan, on "Causalità e interdipendenza nell'analisi econometrica e nella teoria economica" (Pasinetti, 1965).

Pasinetti presented his notion of causality by resorting to two alternative logical structures which represented the relations among the economic variables. The first logical structure may be represented by a system of equations where, given a set of parameters taken as exogenous, all the endogenous variables can be determined by solving simultaneously all the equations of the system. This type of structure, perfectly symmetric, is called by Pasinetti (following Simon), an "interdependent" system (1).

$$
\begin{aligned}
\alpha_{11}x_1 + \alpha_{12}x_2 + \alpha_{13}x_3 + \cdots + \alpha_{1n}x_n &= \alpha_1 \\
\alpha_{21}x_1 + \alpha_{22}x_2 + \alpha_{23}x_3 + \cdots + \alpha_{2n}x_n &= \alpha_2 \\
\alpha_{31}x_1 + \alpha_{32}x_2 + \alpha_{33}x_3 + \cdots + \alpha_{3n}x_n &= \alpha_3 \\
\\
\alpha_{n1}x_1 + \alpha_{n2}x_2 + \alpha_{n3}x_3 + \cdots + \alpha_{nn}x_n &= \alpha_n
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
\beta_{11}x_1 &= \beta_1 \\
\beta_{21}x_1 + \beta_{22}x_2 &= \beta_2 \\
\beta_{31}x_1 + \beta_{32}x_2 + \beta_{33}x_3 &= \beta_3 \\
\\
\beta_{n1}x_1 + \beta_{n2}x_2 + \beta_{n3}x_3 + \cdots + \beta_{nn}x_n &= \beta_n
\end{aligned}
\tag{2}
$$

A second logical structure (2) is represented by an asymmetric system of equations in which each endogenous variable must be determined before and independently of the remaining variables according to a well defined order: we start from x_1, then on the basis of x_1 we determine x_2; then, on the basis of x_1 and x_2 we determine x_3, and so on and so forth. There is a system of logical priorities among the equations of system (2): while the first equation must be solved first and independently from the others, the last equation can be solved only when all the previous equations have been solved:

> Whichever one of the n equations is considered, it can be immediately observed that the equation can be solved only after all the equations which precede it have been solved, and at the same time by ignoring all the equations which follow it. This means that there is an asymmetric relationship among the variables or the unknowns of the system: a relation that acts only in a single direction, and not in the opposite one. Thus, y_n depends on y_1 but y_1 does not depend on y_n. It is in fact this notion of an asymmetric relation among the variables that is here called 'causality'. The ordered sequence of the equations – according to the dependence chain that links them – will be called 'causal order' or 'causal chain' (Pasinetti 1965, p. 237, our translation).

This second type of structure is labeled, following Simon, "causal order" and, following Wold, "causal chain"[5]. In supporting the case for the adoption of causal structure in economic modeling, Pasinetti makes it clear that he does not want to deny the existence of relevant interdependent relations underpinning economic reality: rather, causal or recursive systems may be composed of sub-systems of interdependent equations linked together in a causal chain, as in the case of system (3).

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[5] Actually, Simon's "causal order" is a much broader and general concept, encompassing, but not coinciding with, that of "causal chain" or "recursive system" as formulated by the econometric Swedish school. While the former is formulated in strictly formal terms and does not necessarily imply a time sequence between cause and effect, the latter is certainly more open to a deterministic interpretation and strictly time dependent (see Strotz and Wold, 1960; Drakopoulos and Torrance, 1994, p. 185-187 for a discussion).

$$\begin{bmatrix} \mathbf{A}_{11} & \mathbf{O} & \cdots & \mathbf{O} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{O} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{M1} & \mathbf{A}_{M1} & \cdots & \mathbf{A}_{MM} \end{bmatrix} \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \\ \vdots \\ \mathbf{x}_M \end{bmatrix} = \begin{bmatrix} \mathbf{b}_1 \\ \mathbf{b}_2 \\ \vdots \\ \mathbf{b}_M \end{bmatrix}, \tag{3}$$

where the $\mathbf{A}_{mm}$s are given square indecomposable and non-singular matrices, the **O**s are null matrices, the $\mathbf{b}_m$s are given vectors and the $\mathbf{x}_m$s are unknown vectors respectively.

Recalling the notorious criticisms of the concept of causality stemming from logical positivism, Pasinetti adopted the formal notion proposed by Simon (1953): "causality is to be intended as an analytic characteristic of the relation among the variables within a system rather than a feature of economic reality":

> it is not ... an ontological, but a logical characterization. The two systems, of interdependent equations and of causal equations, are presented as two logical frameworks. And the definition of causal chain which has been provided contains in itself no statement concerning empirical facts. It simply has the meaning of an asymmetric relation between the variables of a logical framework (Pasinetti, 1965, p. 239, our translation).

Actually, theories and models are simplified representations of reality, and Pasinetti's reading of classical and Keynesian contributions reveals how these schools of thought prefer to explain the main economic phenomena by means of causal relations. The adoption of causal, rather than of interdependent relations, is normally the outcome of a selection process among different links and feedbacks among the variables. In particular this choice reflects the selection of *the main* link independently from the feedback effects, which are not denied, but are considered less important to understand the phenomena at stake. Hence, in the theorization process, they are ignored at least in a first approximation.

Moreover Pasinetti discussed the application of the different logical structures to econometrics, suggesting that recursive and causal models present remarkable features of simplicity and robustness (see Pasinetti, 1965, p. 240), while interdependent models need more complex transformations and arbitrary assumptions in order to resolve the identification problems and to overcome the correlation of probabilities between variables and errors[6].

> The reduced form of the interdependent systems, which is of a causal type, allows simpler estimation methods to be applied which can then be re-shaped backwards from the parameters of the reduced form to the parameters of the original form, called "structural", from which they derive. Yet, it is not always possible to keep, in this retransformation, all the statistical properties of the original estimations. In any case, this procedure requires

[6] In the case of interdependent relations: "[t]he probabilistic distribution of the errors of any equation is in these cases correlated to the probabilistic distribution of the non predetermined variables. In order to attain consistent and non distorted parametric estimations … considerably more complicated methods are required, such as, for instance, the maximum likelihood method, which requires laborious, lengthy and complex computations (Pasinetti, 1965, p. 240, our translation).

> particular conditions – the so called "identification" of econometric models – which do not correspond at all to the generality. In other cases, a more complicated procedure has to be applied, in which the estimation of the parameters is made directly on the structural form …. After all, the application of statistical inference to interdependent relationships requires, besides the use of computers, a set of assumptions and hypotheses, and test of these hypotheses, which would not be needed in the case of causal relationships (Pasinetti, 1965, p. 241, our translation).

Pasinetti highlighted how econometric research, especially in the United States, devoted huge human, financial and technical resources, seeking to overcome the problems of structural econometric modeling, while the relatively simple techniques associated with process analysis were apparently cast away and dismissed as devoid of scientific dignity. In this way the efforts undertaken by the Swedish school guided by Wold to develop a causal and dynamic approach to econometrics that Lombardini had long been supporting but most of econometricians had abandoned in search for interdependent structural models. The reason for this preference was to be looked at as a strong theoretical commitment on the part of mainstream economics to develop macroeconomic analysis along the lines of the Walrasian general equilibrium approach. In Pasinetti's view, the debate within econometrics brought to light the existence of two different approaches in economic theory which were dividing the profession in two distinct and opposing fields:

> The discussions that occurred among econometricians appear, in this sphere, as a particular aspect of a broader controversy which is at the foundation of economic theory itself. It is a peculiar yet interesting episode: for the first time these two logical frameworks quite visibly emerge in connection to a very practical purpose: that of quantifying, or estimating parameters of economic relationships (Pasinetti, 1965, p. 246, our translation).

The Walrasian general equilibrium approach gave rise to structural economic models in which the relationship among the endogenous variables should be fully interdependent and perfectly symmetrical. Static comparative analysis should compare the reaction of the system to different external shocks, so that causality could run only from exogenous to endogenous variables. Any internal dynamic process was denied or dismissed as irrelevant: given the set of parameters, the final equilibrium was uniquely determined by the new values of the exogenous variables. Equilibrium analysis did not need any inquiry on the process of disequilibrium (for a discussion see Vercelli, 1991, chapter 2). These features responded to a precise vision of the economic system in which social interaction in the market place occurred between myriads of individuals, each of them endowed with a different set of resources and preferences, but not qualitatively different from each other and, in any case, never able to exert any conscious and relevant power on the final outcome of the whole economic process.

In the following sections we will consider some among the major works by Luigi Pasinetti, where the specification of one or more relations in causal terms plays an

essential role to convey an economic result that would emerge less clearly, or would not emerge at all, if the same relations were represented in an interdependent way.

3. Causality in Ricardian analysis

Let us start from Pasinetti's approach to Ricardo. In the aforementioned inaugural lecture Pasinetti says:

> [c]onsider, for example, the Ricardian central theory — that of the distribution of global income among the various social groups participating in the production process[7]. — The various categories of incomes are determined according to a clear sequence: wages first (on the basis of the physiological necessities of life), then rent (according to the varying fertility of the soil) and finally profits, as residual income (Pasinetti, 1965, p. 244, our translation).

This causal ordering emerges very clearly from the one industry Ricardian model proposed by Pasinetti (1977, chapter 1, § 3.1) elaborated on the basis of Kaldor (1956, § I). Let $Q_c = f(N_c)$ be the corn produced as a function of the number of workers, N_c, employed in producing corn,

$$W = \bar{x}N_c \tag{4}$$

be total wages ($\bar{x}$ being the unit subsistence wage) and

$$R = f(N_c) - N_c f'(N_c) \tag{5}$$

be the rents determined according to the varying degree of fertility of the various pieces of cultivated land. Profits, P_c, and the rate of profit, r, are determined by

$$P_c = Q_c - W - R = N_c[f'(N_c) - \bar{x}] \tag{6}$$

and

$$r = \frac{f'(N_c) - \bar{x}}{\bar{x}}. \tag{7}$$

After deducting rents, profits are the surplus of corn over wages obtained on the marginal land. This residual character of profits reflects clearly the primacy of capitalists in the production process. This view requires precise *causal* ordering: all magnitudes concurring to calculate profits, that is, output of corn, wages and rents must be *priorly* known *before* profits are determined. It is thus easy to observe that these magnitudes depend all on N_c, which in the one industry model is entirely determined by the amount of capital available, $\overline{K}$, and by the subsistence wage rate, $\bar{x}$:

[7] D. Ricardo, *On the Principles of Political Economy and Taxation*, London, 1821.

$$N_c = \overline{K} / \bar{x} \tag{8}$$

(capital is constituted only by wages advanced to workers at the beginning of the productive process).

The clearness of these results is soon put at risk (see, for example, Costa, 1977, §1), if the analysis is extended to a second industry, 'gold', in the Pasinetti formulation (see 1960 and 1977, chapter I, § 3.2-3.5), since N_c requires a more complex determination. Still, capital consists entirely by wages advanced but, in this case, workers are employed in two different sectors:

$$N_c + N_g = \overline{K} / \bar{x}\,, \tag{9}$$

where N_g are workers employed in the gold industry. Gold is produced under constant returns to scale, on the basis of the following production function:

$$Q_g = \alpha N_g, \qquad \alpha > 0. \tag{10}$$

Following Ricardo's early approaches to profit theory, as underlined by Sraffa (1951, Section IV) the corn industry is in the special position to be able to determine its rate of profit independently of the price system, being its output and its input constituted by the same commodity, i.e. corn (see our equation (7)). This independence confers to the corn industry the rôle of determining the rate of profit of the whole system,[8] in the sense that the rate of profit of the gold industry aligns to the rate of profit of the corn industry:

$$\frac{p_g Q_g - p_c \bar{x} N_g}{p_c \bar{x} N_g} = \frac{f'(N_c) - \bar{x}}{\bar{x}}\,. \tag{11}$$

This alignment takes place thanks to a suitable variation of the relative price of gold in terms of corn, whose level can be deduce from (11)

$$\frac{p_g}{p_c} = \frac{1/\alpha}{1/\, f'(N_c)} \tag{12}.$$

From this formulation it emerges that all relevant economic variables (total profits, the rate of profit, rents, the relative price, ...) depend crucially on N_c, the number of workers employed in the corn industry. In the whole system the total quantity of workers is driven by $\overline{K} / \bar{x}$.

[8] For details, see Bellino (2014, in particular Section 3). Pasinetti (1960) did not resort to this device to determine the overall rate of profit; yet, the same expression for the rate of profit is obtained.

In order to split workers between the two sectors, it is necessary to determine the *composition* of total expenditure. Pasinetti resorts to a theory of expenditure (1960, p. 84) or a theory of demand (1977, p. 14). He supposes that workers and capitalists spend their incomes (wages plus profits) on corn (the former as necessities, the latter for capital accumulation), while land-owners spend their rents entirely on gold. To this purpose, it is sufficient to specify the expenditure of land-owners:

$$p_g Q_g = p_c R. \tag{13}$$

But, this closure of the model irreparably undermines the Ricardian explanation of income distribution. The system of equations regulating income distribution (4), (5) and (6) is no longer closed by the knowledge of the amount of available capital which, by (8), determines the amount of corn produced. Income distribution now depends also on the composition of final demand and on prices. For example, it is sufficient to subvert the assumption that land-owners consume just gold in order to see the breakdown of the entire causal structure. Suppose that a fraction $(1 - \beta)$ of rents is spent on gold, while a fraction β is spent on corn, $0 \leq \beta \leq 1$. Equation (8) becomes[9]

$$p_g Q_g = (1 - \beta) p_c R. \tag{8′}$$

Substitute (10), (5) and (9) into equation (8′); re-arrange and obtain:

$$\frac{\overline{K}}{\bar{x}} = (1-\beta)\frac{f(N_c)}{f'(N_c)} + \beta N_c . \tag{14}$$

If $\beta = 0$, that is, rents are entirely spent on gold, like in Pasinetti's case, equation (14) reduces to

$$\frac{\overline{K}}{\bar{x}} = \frac{f(N_c)}{f'(N_c)} . \tag{14′}$$

Let N_c^* be the solution of (14′), that is the number of workers employed in the industry of corn in the case that rents are entirely spent on gold. As we relax this extreme assumption, and we allow for the consumption of corn also by land-owners, β moves from zero to a positive value; accordingly, the solution for N_c, and thus all the

[9] As in the case considered by Pasinetti, this demand equation is sufficient to specify the demand of corn, which now equals wages + profits + a fraction β of rents. In fact, by substituting (8′) into the expression of profits, $rp_cK = p_cQ_c + p_gQ_g - p_cR - wN$, we have $rp_cK = p_cQ_c + \beta p_cR - wN$, that is, $p_cQ_c = wN + rp_cK + \beta p_cR$, which is the relation required.

fundamental variables of the system, that is, rents, profits, the rate of profit and the price of corn, will change with β, that is, with changes of final demand!

The dependence of profits on prices, which was accurately discarded by Pasinetti's assumption that in the system there is only one capital good (which coincides with the device used by Ricardo in his early writings to consider 'corn' as that commodity having the property of being both the input and the output of its production) is promptly reinstated by closing the system with a demand theory.

What differentiates the present model from a general equilibrium system? Only disequilibrium in the labour market, induced by the assumption of a given real wage rate (equal to the subsistence level), and a theory of value which expresses the labour theory of value.[10] Moreover, relative prices would come to depend on N_c, that is, on final demand, in contrast to the conclusion drawn by Pasinetti that "it appears that the value of commodities depends exclusively on technical factors (the quantity of labour required to produce them) and on nothing else" (Pasinetti, 1960, p. 85), as argued by Costa (1977, § 1). From the formal point of view, this argument is correct: we are in a *simultaneous* equation system.

There is, however, a better glass through which the Ricardian system can be looked at. As it is well known, it is common for the Classical approach to distinguish between two levels of analysis: one, more fundamental, where the relations between the distributive variables and the normal prices of commodities are described, and a second level, where the 'institutional' aspects, in a broad sense, are taken into account.[11] The Ricardian system here outlined is a typical example of where this distinction becomes relevant. Relation (13) is a relation which attains to an institutional aspect (or it is better studied 'outside of the core') as it describes the behaviour of land-owners in spending rents and, in a specular way, that of workers and capitalists in spending wages and profits respectively. These consumption behaviours may be contingent on the historical phase (like the assumption of a subsistence wage rate[12]). Hence, the rule implicit in

[10] This result, which is the consequence of the simplifying assumption that capital is constituted only by the corn advanced to workers as subsistence, can easily be deduced by equation (12) by observing that $1/\alpha =: \ell_g$ is the quantity of labour necessary to produce 1 unit of gold and $1/f'(N_c) =: \ell_c$ is the quantity of labour necessary to produce 1 unit of corn on the marginal land; in this way equation (12) can be re-expressed as $p_g/p_c = \ell_g/\ell_c$.

[11] Pasinetti distinguishes between a 'natural' and an 'institutional' level. Garegnani (1984) distinguishes between a 'core' system and the relations 'outside of the core'. These distinctions do not overlap, but share several common characteristics. An analysis of and a comparison between these distinctions are the subject of an ongoing research by one of the present authors.

[12] As outlined by Garegnani: 'at a closer inspection, what all these authors had in common was not, as is often held, the idea of a wage determined by subsistence. It was the more general notion of a real wage governed by conditions (often of a conventional or institutional kind) that are *distinct* from those affecting the social product and the other shares in it, and are therefore best studied separately from them. This separation between the determination of the wage and that of the social product is evident when, as in Quesnay or Ricardo, the wage is explained in terms of a customary subsistence, but the same separation between the two problems emerges in Marx and Smith, who admitted a greater influence of current economic conditions on the real wage. It is this separate determination of the real wage that is expressed in its treatment as a magnitude which is known when the determination of the other shares of the product is approached" (Garegnani, 1984, pp. 295-6).

equation (13) is just *one* of the possible ways to describe the determination of the composition of final demand of the system. This determination depends on several elements beside market prices such as habits, customs, historical circumstances, etc., in brief, institutional elements, which make this determination subject to various, transitory and often non univocal forces. This makes quite hard the possibility of describing the composition of final demand by means of a univocal function of the other variables of the system. It seems more appropriate to adopt the same perspective followed by Sraffa (1960), that is, to consider no changes in the composition of output (for a detailed analysis of this supposition as a peculiar feature of the method of Classical economists, see Garegnani, 1984, Section II; see, also, 2007). By following this suggestion, the Ricardian model proposed by Pasinetti immediately recovers the causal structure necessary to ground an explanation of profits based on the notion of surplus. Let $\overline{Q}_c$ and $\overline{Q}_g$ be the given quantities of the corn and gold produced. Through their respective production function, we obtain immediately the total labour requirements to produce those quantities: $N_c^* = f^{-1}(\overline{Q}_c)$ and $N_g^* = \overline{Q}_g / \alpha$.[13] Prices, wages, rents, profits and the rate of profit are thus univocally determined:

$$\frac{p_g}{p_c} = \frac{1/\alpha}{1/f'(N_c^*)},$$

$$W = \bar{x}(N_c^* + N_g^*),$$

$$R = f(N_c^*) + N_c^* f'(N_c^*)$$

and

$$r = \frac{f'(N_c^*) - \bar{x}}{\bar{x}}.$$

All crucial characteristics of the Ricardian theory of value and distribution claimed by Pasinetti get reinstated: i) the sequential determination of distributive variables and, in particular, the residual character of profits, as emphasized by Pasinetti (1965, p. 244); ii) "a theory of value which is completely and (owing to our explicit assumptions) rigorously independent of distribution" (Pasinetti, 1960, pp. 84-5) and iii) "a theory of income distribution which is independent of the theory of value" (Pasinetti, 1977, p. 15).

[13] In this case it is no longer true that $\bar{x}(N_c^* + N_g^*) = \overline{K}$; we have to introduce the condition that the solution with respect to N_c and N_g satisfies $\bar{x}(N_c^* + N_g^*) \leq \overline{K}$. Alternatively, if we drop the supposition that the stock of capital is given, the amount of capital necessary to produce the given quantities $\overline{Q}_c$ and $\overline{Q}_g$ would be determined endogenously by the model.

4. Causality in Keynesian analysis

Pasinetti highlights how the main pillar of Keynes's *General Theory* is the *principle of effective demand*, according to which, below full employment, the level of aggregate output Y of an industrial economy, is *determined* by the level of aggregate effective demand D, constituted by consumption C, investments I, and public expenditure G (for simplicity, we abstract from imports and exports). This principle represented a break with the tradition that held aggregate output be co-determined by the interaction of supply and demand forces and full employment be attained by means of price and wage adjustments. Evidently, this principle should be represented by a *causal* equation, in the sense that $D \rightarrow Y$ (Pasinetti, 1974, pp. 46-48). A second element of Keynes's theory was an explanation of the rate of interest, r, essentially *as a purely monetary phenomenon*. This represented another break with the tradition that saw the rate of interest as the price of capital, determined by the interaction between the demand of investment and the supply of savings. To this purpose, Keynes was careful to link aggregate consumption, C, just to national income, Y (and not to r): $C = A + cY$, where A is the autonomous consumption and $c \in (0,1)$ is the marginal propensity to consume. In this way, aggregate savings turn out to be released from r and are given by $S \equiv Y - C - G = -A - G + (1 - c)Y$. On the contrary, investments are not put in relation with national income; they depend positively on their expected profitability, E, and negatively on the rate of interest, $I = I(E, r)$. According to Pasinetti (1974, p. 37) entrepreneurs rank investment projects according to their decreasing expected profitability and carry out investments up to the point at which the expected rate of profit of the last project (the 'marginal efficiency of capital') is higher than or equal to the rate of interest. [14] Hence, a decrease of the rate of interest enlarges the number of projects carried out. It is now necessary to explain what determines the rate of interest. This is the third original contribution given by Keynes: the *liquidity preference* function. Individuals prefer to keep their wealth in liquid form (for transactions, precautionary and speculative reasons), unless a positive interest rate is paid when the same amount of wealth is kept in less liquid financial activities; hence the demand for money is inversely related to the rate of interest: $L(r)$. The Central Bank fixes the amount of money supplied, $\overline{M}$; the rate of interest is thus given by the solution of

$$L(r) = \overline{M}, \quad \text{that is,} \quad r = r^*. \tag{15}$$

[14] This Ricardian interpretation of the notion of the 'marginal efficiency of capital'—which looks like a possible re-interpretation of Keynes investment theory rather than an attempt to interpret what Keynes actually thought—is not shared by other authors; Garegnani for example considers the 'marginal efficiency of capital' "the price which Keynes has to pay for the traditional strand in his thought" (1979, p. 78) *r*. On this point see also Tonveronachi (1983, p. 169).

Hence, given the state of business expectations regarding the future return on new investments (here summarized by symbol E), the level of investments is given by[15]

$$I^* = I(E, r^*). \tag{16}$$

Effective demand, $D = A + cY + G + I(r)$, depends on national income only; by the principle of effective demand, $Y = D$, and we are thus able to determine the equilibrium levels of national income and consumption:

$$Y^* = \frac{1}{1-c}[A + I(r^*) + G] \quad \text{and} \quad C^* = A + cY^*. \tag{17}$$

Pasinetti highlights that an evident *causal* ordering regulates the relationship between the rate of interest—which is determined by the money market equilibrium—and investments—which are determined by the marginal efficiency of capital and the rate of interest. An *interdependent* sub-system determines the remaining variables: national income, savings and consumption.

Such a hierarchical determination of the endogenous variables does not merely reflect a formal property. It is fundamental in conveying substantial results of Keynes's system.

K1) A first result is the process of generation of national income: it is ultimately determined by expenditure decisions: A, $I(r^*)$ and G.

K2) A second relevant result is the relation between investments and savings: investments are an exogenous variable with respect to the sub-system which determines national income. Savings adjust themselves passively to investment levels: $S = Y - C - G = (C + I + G) - C - G = I$. Given *any* level of I, as determined by equation (16), the principle of effective demand will give rise exactly to that level of national income which will ensure the amount of savings necessary to finance that level of investment.

Therefore, it can be seen that the *causal relation* between I to S (i.e., $I \rightarrow S$) rests on the possibility to consider investments as given with respect to the process which generates national income and savings. Not surprisingly, the unhinging of this property was the starting point of the Neoclassical synthesis originally proposed by Hicks (1937). Paradoxically, the evidence for this 'generalization' is provided in the 15th chapter of the *General Theory* by Keynes himself, who acknowledges that the demand for liquidity for transaction- and precautionary-motives depends on the level of national income. The functional form of the liquidity preference function written by Keynes (1936, p. 199) is

[15] As the expected profitability of investments (denoted by symbol E) is to be considered independent of the other endogenous variables of the system, we will omit to explicitly indicate it throughout the rest of the paper, and we will write $I = I(r)$. A criticism is raised on this point by Garegnani (1979, p. 78fn), who says: "there are some arguments for which the assumption of prospective yields and prices independent by the ruling interest rate does not seem acceptable".

$L_1(Y) + L_2(r)$, where $L_1(Y)$ is the liquidity demanded for transaction- and precautionary-motive and $L_2(r)$ is the liquidity demanded for speculative-motive. The equilibrium of the money market is thus represented by the condition

$$L_1(Y) + L_2(r) = \overline{M}\,, \qquad (15')$$

where $\overline{M}$ is the stock of money provided by the banking system. System (15′), (16) and (17) is now a fully *interdependent* system. The causal determination of endogenous variables contained in equations (15), (16) and (17) and, consequently, the properties K1) and K2) above are thus immediately lost!

> In this way ... demand for money is made to depend not only on the rate of interest but also on income. At the end of this, apparently innocuous, manipulation, Hicks has in fact broken up Keynes's basic chain of arguments. The relations have been turned into a system of simultaneous equations, i.e. precisely into what Keynes did *not* want them to be (Pasinetti, 1974, p. 46).

In his 1974 essay Pasinetti does not clarify the arguments that Keynes offered to deny the alleged influence of income on the demand for money and thus on the rate of interest. He mentions the quarrel on the *finance motive* which developed immediately after the publication of the *General Theory* with Dennis Robertson, before presenting a 'lagged' version of the multiplier that show that this process equates total savings to the realized investments only after its completion.

The finance motive quarrel shows how stubbornly, though not without falling into some inconsistency and indecision, Keynes strove to maintain that savings and investments do not exert any influence on the rate of interest and thus to preserve its purely monetary nature[16]. Yet Keynes did not pay much attention to the IS-LM model (he declared, in a letter to Hicks, to have "found it very interesting and really have next to nothing to say by way of criticism") and tended to assimilate Hicks' interpretation of the rate of interest to that presented by Ohlin and Robertson.[17]

Pasinetti must have had his own reasons for thinking that the economic system outlined in the *General Theory* is better represented by the *causal* system (15), (16) and (17) instead of the interdependent system (15′), (16) and (17). In actual economic systems, it is reasonable to assume that the banking system and the central bank try to satisfy, in each period, the fluctuation of the demand for monetary transactions- and for

[16] On this point see Trevithick (1994, 84-85) and Cesaroni (2001, pp. 62-63). The debate on the finance motive revived in the 1980s between monetarist and post-keynesian interpreters of Keynes'ss monetary thought. While Asimakopulus (1983) highlights a disequilibrium between saving and investments before the end of the multiplier process, Graziani (1984, 1986), Terzi (1986, 1987), Kregel (1986) and Davidson (1986) presented the view that "irrespective of the saving decisions being taken on the income that derives from the expenditure of fixed capital *finance*, at the end of the circulation period an adequate quantity of long-term *finance* will be available to restore the initial liquidity position of the banks" (Cesaroni 2001, p. 63).

[17] CWJMK, XIV, pp. 202-205.

precautionary-motives with suitable changes in the stock of money supplied, so that the term $\overline{M} - L_1(Y)$ can reasonably be considered as a constant, and (15′) returns to be an equation with the single unknown *r*:

$$L_2(r) = \underbrace{[\overline{M} - L_1(Y)]}_{\text{constant}}; \qquad (15'')$$

the *causal* ordering is thus re-established in system (15′′), (16) and (17).

Pasinetti's view may be in line with more recent interpretations of Keynes's monetary theory offered by other streams of post-Keynesian literature. For example, Wray (1992) reconciles Keynes's theory of liquidity preference as presented in the *General Theory* with the endogenous money supply typical of the *Treatise on Money*. A growth in national income due to additional government expenditures is associated with an increased demand for money for transaction- and precautionary-motives.[18] Yet the additional demand deriving from the above mentioned motives can be smoothly satisfied by the banking system, which will be willing to expand its credit facilities at the current rate of interest. While the money supply will spontaneously accommodate income growth, the rate of interest will not be affected. On the contrary, an increase in liquidity preference directly affects the rate of interest (and the prices of financial assets) and will not be met by the banking system with an increase in the money supply: banks themselves will exert demand for new liquidity, retain the liquidity they own and lower their asset/reserve ratio.[19]

5. Causality in structural change analysis

The interactions between causal and interdependent relations play a fundamental role also in the most accomplished work presented by Pasinetti, i.e. the framework to analyse the structural change of a growing economy. There are at least two levels where the distinction between causality and interdependence is crucial: the choice to represent the production processes in vertically integrated terms and the way in which the dynamics of output is studied without compromising the logical structure of the surplus approach.

[18] The finance motive stemming from disequilibrium between saving and investment during the multiplier process could be added as a third factor.

[19] The central bank will be called to expand its own supply of liquidity to the banking system and engage in open market purchases in order to drive asset prices up and interest rates down: in this case, the money supply apparently ceases to be endogenous, a point which Wray fails to notice (Wray 1992: 86-87). Thus, while the central bank may be able to counteract the upward pressure of liquidity preference on interest rates and asset prices, it may fail to make commercial banks willing to purchase assets and expand their credit facilities. Uncertainty and liquidity preference will still prevent a secondary expansion of the money supply.

5.1. Vertically integrated representation of production processes

Consider a system where final M commodities are produced by employing capital goods and labour. Let $m = 1, ..., M$ be the index corresponding to each commodity. For simplicity, we will consider the case where capital goods are produced just by labour.[20] We represent this economy by means of a closed Leontief system, i.e. a model which is typically employed to represent inter-industrial *interdependences*. But the aim of the analysis is to investigate how the *size* and the *structure* of an industrial economic system evolve as a result of the joint pressure of: i) population change, ii) technical change and iii) the change of final demand composition. Element i) operates substantially on the scale of the system, but elements ii) and iii) operate also on the *composition* of inter-sectoral relations. In analytical terms, let

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1M} & c_1 \\ a_{21} & a_{22} & \cdots & a_{2M} & c_2 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{M1} & a_{M2} & \cdots & a_{MM} & c_M \\ \ell_1 & \ell_2 & \cdots & \ell_M & 0 \end{bmatrix}$$

be the matrix of input-output coefficients, where the generic a_{mi} coefficient is the quantity of commodity m used to produce 1 unit of commodity i, ℓ_m is the quantity of labour necessary to produce 1 unit of commodity m and c_m is the per-capita consumption of commodity m. Element ii) affects coefficients a_{mi} and ℓ_m while element iii) affects coefficients c_m; in addition, both ii) and iii) affect the number M of commodities used as final goods as well as capital goods.

To set up a model where all these magnitudes change is quite a difficult task. The device adopted by Pasinetti has been that of measuring capital goods in terms of units of 'vertically integrated productive capacity' (see Pasinetti, 1981, chapter II, § 4). One unit of vertically integrated productive capacity of commodity m is the set of "heterogeneous physical quantities of the various commodities 1, 2, ..., M, which are directly and indirectly required as stocks, in the whole economic system, in order to obtain one physical unit of commodity m as a final good" (Pasinetti, 1973, § 4, notation adapted). Thanks to this device, the input of capital goods is represented by a *single* entry: $\delta_m = 1/T_m$, where T_m is the average life-time of the set of physical capital goods employed in the vertically integrated sector of commodity m;[21] for simplicity, we assume that this fraction is constant over time. Moreover, let λ_m be the quantity of labour required to produce one unit of productive capacity of final commodity m; let j_m

[20] The general case, capital goods produced by labour and capital goods, is considered in Pasinetti (1981, chapter II, §7).

[21] The case considered here is that capital goods last for more than one period (i.e., fixed capital); the case of circulating capital can be obtained as a particular case if $T_m = 1$ and, consequently, $\delta_m = 1$.

be the coefficient of individual demand of capital good m by the final sector (net investment); let N denote the population size. Let x_m and k_m be the quantities produced of final good m and of its productive capacity respectively, and let p_m and q_m be the corresponding prices. Finally, let w be the wage rate and π_m the corresponding rates of profits (that for the moment are not assumed to be uniform among sectors). δ_m, l_m, λ_m, c_m, j_m, and N are the *data* of the model; x_m, k_m, p_m, q_m, w and the π_ms are the *unknowns* of the model. The quantity system is

$$\begin{bmatrix} 0 & \cdots & 0 & 0 & \cdots & 0 & c_1 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & 0 & \cdots & 0 & c_M \\ \delta_1 & \cdots & 0 & 0 & \cdots & 0 & j_1 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & \delta_M & 0 & \cdots & 0 & j_M \\ l_1 & \cdots & l_M & \lambda_1 & \cdots & \lambda_M & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_M \\ k_1 \\ \vdots \\ k_M \\ N \end{bmatrix} = \begin{bmatrix} x_1 \\ \vdots \\ x_M \\ k_1 \\ \vdots \\ k_M \\ N \end{bmatrix}. \qquad (18)$$

The first $2M$ equations of system (18) determine the quantities produced of each good according to its effective demand: the first M equations concern final goods; the second M equations concern the productive capacity of final goods, and show the two components of demand for productive capacity: replacement ($\delta_m x_m$) and net investments ($j_m N$). The last equation of system (18) establishes that in equilibrium, labour requirements (in producing final goods and their productive capacities) must equal the existing labour force.

The price system is:

$$\begin{bmatrix} 0 & \cdots & 0 & \pi_1+\delta_1 & \cdots & 0 & l_1 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & 0 & \cdots & \pi_M+\delta_M & l_M \\ 0 & \cdots & 0 & 0 & \cdots & 0 & \lambda_1 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & 0 & \vdots & 0 & \lambda_M \\ c_1 & \cdots & c_M & j_1 & \cdots & j_M & 0 \end{bmatrix} \begin{bmatrix} p_1 \\ \vdots \\ p_M \\ q_1 \\ \vdots \\ q_M \\ w \end{bmatrix} = \begin{bmatrix} p_1 \\ \vdots \\ p_M \\ q_1 \\ \vdots \\ q_M \\ w+\sum_{m=1}^{M} \pi_m q_m c_m \end{bmatrix}. \qquad (19)$$

The first $2M$ equations of system (19) determine prices of final goods and of their productive capacities. The last equation of this system refers to *net* national income and states that in equilibrium wages plus profits must equal the expenditure for final and investment goods.[22]

[22] In order to justify the expression of the last equation of system (19), observe that profits are calculated by applying the sectorial rate of profit to the value of the capital goods stock existing in the respective

The vertically integrated representation here adopted has hidden all inter-industrial interdependences, as a simple inspection of the matrices involved in systems (18) and (19) confirms: the sub-systems represented by the first 2*M* equations of both the quantity- and the price-system are formally *decomposable*; their solutions are, respectively,

$$x_m = c_m N, \qquad m = 1, ..., M, \qquad (18x)$$

$$k_m = \delta_m x_m + j_m N, \qquad m = 1, ..., M, \qquad (18k)$$

and

$$p_m = (\pi_m + \delta_m) q_m + w l_m, \qquad m = 1, ..., M, \qquad (19p)$$

$$q_m = w\lambda_m, \qquad m = 1, ..., M. \qquad (19q)$$

As regards the quantities, given *N*, each equation (18x) *immediately* determines the output of the respective final commodity: $x_m^* = c_m N$; *after substitution*, each equation (18k) determines the output of the correspondent number of new units of vertically integrated productive capacity, $k_m^* = \delta_m x_m^* + j_m N$. As regards prices, we *first* calculate the price of the capital good (i.e. the productive capacity necessary to produce one unit) of each final commodity *m*: $q_m^* = w\lambda_m$; *then* we calculate the price of each final good, $p_m = (\pi_m + \delta_m) q_m^* + w l_m$.[23]

As observed before, the technical interdependences among sectors have completely *disappeared*. Each vertically integrated sector remains defined by a couple of equations on the quantity side (one for the output of the final commodity and one for the output of its productive capacity) and a couple of equations for the price side (one for the price of the final commodity and one for the price of its productive capacity). Within each vertically integrated sector, there is a hierarchy between each of the couple of equations, as described above. Finally, each vertically integrated sector is independent of the others, both on the quantity and on the price side.

However, interdependence reappears if we look at the system in its entirety, that is, if we impose the contemporaneous fulfillment of the 'macro-economic condition':

$$\sum_{m=1}^{M} l_m c_m + \sum_{m=1}^{M} \lambda_m j_m + \sum_{m=1}^{m} \delta_m \lambda_m c_m = 1. \qquad (20)$$

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vertically integrated sector of final commodity *m*; the device to measure capital goods in terms of the unit of vertically integrated productive capacity entails that the number of units of vertically integrated productive employed in sector *c* coincides with the number final units of commodity *m* actually produced, i.e., x_m. Hence, total profits of the system are expressed by the sum $\Sigma_{m=1}^{M} \pi_m q_m x_m$. By solving the first *M* equations of the quantity system, one yields $x_m = c_m N$, $m = 1, ..., M$. Hence total profits can be re-expressed as $\Sigma_{m=1}^{M} \pi_m q_m c_m N$. The original formulation of the last equation of the price system is thus $\Sigma_{m=1}^{M} p_m c_m N + \Sigma_{m=1}^{M} p_m j_m N = wN + \Sigma_{m=1}^{M} \pi_m q_m c_m N$; after dividing by *N* we obtain the last equation of the price system as expressed in (19).

[23] As is well known, the price equations do not entail a unique configuration for income distribution. In the case of a uniform rate of profit and a uniform wage rate, we must fix *w* or π outside the price equations. In the present case, with *M* rates of profits and a uniform wage rate, we must fix up to *M* among the variables $\pi_1, ..., \pi_M$ and *w* outside the price equations. Obviously, a constraint must be imagined to hold, in order to avoid that some of these variables become negative.

It is quite easy to verify that condition (20)—which is the necessary and sufficient condition to exclude trivial solutions to systems (18) and (19)—ensures that: i) the solutions of the quantity system satisfy also the last equation of system (18), that is, the full employment condition and ii) the solutions of the price system also satisfy the last equation of system (19), that is, the condition of complete expenditure of wages plus profits. The decomposability of systems (18) and (19) entails that it is possible to conceive situations where just the first 2*M* equations of the quantity system and/or the 2*M* first equations of the price system are satisfied, while the last equation of both system is not: we would have thus a sectoral equilibrium (as regards output and/or prices) and a macro-economic disequilibrium (on this, see Pasinetti. 1993, p. 23).

Due to the enormous simplifications made possible by vertical integration, Pasinetti is now in the condition to introduce population dynamics, technical progress and changes in consumer tastes by assuming that

$$N(t) = N(0)\mathrm{e}^{gt}, \quad l_m(t) = l_m(0)\,\mathrm{e}^{-\rho_m t}, \quad \lambda_m(t) = \lambda_m(0)\,\mathrm{e}^{-\rho'_m t} \quad \text{and} \quad c_m(t) = c_m(0)\,\mathrm{e}^{r_m t}:$$

g is the growth rate of population, ρ_m and ρ'_m are the (given) rate of decrease of the labour coefficient in the final commodity vertically integrated sector and in the vertically integrated sector of its productive capacity (ρ_m and ρ'_m are the rates of increase of labour productivity in the respective vertically integrated sector), and r_m is the (given) rate of change of final demand of commodity *m*. In principle, $\rho_m \neq \rho_h$, $\rho'_m \neq \rho'_h$ and $r_m \neq r_h$ (by simplification, N, l_m, λ_m and c_m are supposed to vary with at *constant* rates of change; Pasinetti, 1981, pp. 82-3, suggests how this simplification can be removed). Moreover, the assumption that technical change and final demand coefficients evolve according to a *given* dynamics is a requirement to make this analysis coherent with the logical requirements of the surplus approach (see below; for further details on this see also Bellino, 2014).

The dynamics of all the parameters of systems (18) and (19) are all specified except for the dynamics of the per-capita investment coefficients, j_m. In order to set up the productive capacity for each final commodity *m* in line with the dynamics of its demand in each period, it is necessary that coefficients j_m evolve according to the following dynamic equilibrium condition:[24]

$$j_m(t) = (r_m + g)c_m(0)\,\mathrm{e}^{r_m t}.$$

It is remarkable how the operation of vertical integration makes it easy to describe the effects of technical progress in our system. Obviously, innovations take place at the level of the various industries; yet, by means of vertical integration we 'pick

[24] For details, see Pasinetti (1981, Chapter V, Section 4).

up' what happens in each industry and we observe its non-uniform total effects 'resumed' in the form of changes (typically reductions) of just two vertically integrated labour coefficients for each final commodity.

5.2. Changing quantities and 'given quantities'.

Now we are able to consider a second sphere of Pasinetti's structural change model where the choice to avoid interdependencies reflects a well-defined theoretical requirement. This model is considered by Pasinetti (2007, Book Three, and 2012) as the main direction along which to develop Sraffa's framework. As was recalled at the end of Section 3, the assumption of given quantities, commonly adopted by old and modern classical economists in analysing the determination of profits and prices, is crucial in the surplus approach to avoid any co-determination between quantities and prices that could reintroduce a deterministic explanation of income distribution on the basis of demand curves of final goods and supply curves of productive factors (a detailed analysis of this point was developed by Garegnani, 1983 and 2007). But in the structural change model, the quantities produced of the various commodities, as well as the quantities of commodities which are employed as means of production, *must* change: this is a framework which aims to describe the *dynamics* of the structure of an economic system. In other words, on the one hand, the dimension and the composition of the economic system must be considered as given when determining the rate of profit, the wage rate and relative prices; on the other hand, both the dimension and the composition of the system must necessarily change if the system undergoes a process of structural change.

Now, it is easy to verify that the way followed by Pasinetti to introduce dynamics in the model is fully compatible with the methodology of the surplus approach. In fact, the dynamics supposed for the parameters of the model (population, technical coefficients and final demand), which induce structural dynamics on the endogenous variables of the model (quantities produced and prices),[25] is outlined as completely *independent* of these variables. This device prevents any possible double closure of the circuit (prices depending on quantities and quantities depending on prices) and keeps the structural change model fully compatible with the logical structure of classical theories. Any attempt to 'endogenize' the changes—sometimes invoked as a useful 'generalization' of the model—would be probably incompatible with the logic of the modern classical approach.

6. Causality in income distribution: the Cambridge equation

There is a further sphere of the classical-Keynesian approach where the specification of a theory by means of a causal relation actually conveys a peculiar vision about the matter of the theory: it is the case of the post-Keynesian theory of income distribution,

[25] For a detailed description, see Pasinetti (1981, Chapter V, Sections 9-12).

originally formulated by Michal Kalecki (1939), Nicholas Kaldor (1956), Joan Robinson (1956), David G. Champernowne (1958) and Richard Kahn (1959). The main theoretical outcome of their investigations is contained in the so-called Cambridge equation, which was subsequently generalized by Pasinetti (1962). It emerges as an attempt to apply the principle of the multiplier to the phenomenon of income distribution between profits and wages, when full employment prevails, on the basis of the idea, advanced by Keynes, that "profits, as a source of capital increment for entrepreneurs, are a widow's cruse which remains undepleted however much of them may be devoted to riotous living" (Keynes, 1930, Vol. I, p. 39). Without entering into details (the interested reader can see Kaldor, 1956, Section IV and Pasinetti, 1974, essays IV and V) we can outline the main results of the post-Keynesian theory of income distribution as follows. Denote profits by P, investments by I, the social product by Y, the value of capital by K, the propensity to consume of capitalists by s_c, the capital-output ratio by κ, and the rate of growth of population by g_n; the post-Keynesian theory of income distribution is identified by

$$P = \frac{1}{s_c} I, \tag{21a}$$

$$\frac{P}{Y} = \frac{1}{s_c} \kappa g_n \tag{21b}$$

and

$$\frac{P}{K} = \frac{1}{s_c} g_n . \tag{21c}$$

These expressions give the profit level, the profit share and the rate of profit respectively able to finance a growth of the system compatible with the maintenance of full employment of productive capacity and of labour force. Equation (21a) expresses the relation between investments (considered as an independent variable) and profits in the form of a multiplier and explicates Keynes's idea of profits as a 'widows' cruse', although referring to capitalists' expenditure in general and not to expenditure in consumption goods only: in fact, equation (21a) can be re-written as

$$P = C_c + I, \tag{21a′}$$

where $C_c = (1 - s_c)P$ is capitalists' consumption. It shows how an increase in investments as well as in the expenditure on consumption (a decrease in s_c) increase profits; only capitalists' expenditure decisions are relevant to determine the profits level for the system as a whole (on this, see also Kalecki, 1942, in particular, § 2). This result upsets the Ricardian causal relation between profits and accumulation, according to which profits determine investments. Relation (21b) emphasizes a strong result: given κ, s_c and g_n, the profit share (and thus the wage share) remains constant through time;

this entails that the wage rate can increase at a rate equal to the rate of increase of labour productivity. Relation (21c), the so-called 'Cambridge equation', identifies the rate of profit of the whole system.

Equations (21) were initially obtained by Kaldor (1956) by assuming that overall savings come from profits only, i.e. by assuming $s_w = 0$; consequently, his general expressions of equations (21) were more complicated. Pasinetti fixed a logical slip of Kaldor's model, and showed that relations (21) are actually valid also in the general case where $s_w \neq 0$.

In order to understand the logic of Pasinetti's theorem, consider that in a dynamic equilibrium the capital endowment of each social class must grow at the same rate, i.e.

$$\frac{S_w}{K_w} = \frac{S_c}{K_c} \tag{22}$$

(should condition (22) be not satisfied, the share of capital owned by one of the two classes would become infinitesimal with respect to the other in the long run; on this, see Kurz and Salvadori, 1995, pp. 586-7). Dividing the denominators of (22) by the rate of profit, r, one obtains $S_w/P_w = S_c/P_c$, where $P_w = rK_w$ and $P_c = rK_c$ are the profits of workers and capitalists (obviously, $P_w + P_c = P$). As $S_w = s_w(W + P_w)$, $S_c = s_cP_c$, equation (22) can be re-written as

$$s_cP_c + s_w(W + P_w) = s_c(P_c + P_w). \tag{22′}$$

From (22′) we see that the overall savings of the system (the left-hand side) is equal to the amount that would be saved by capitalists if the overall profits were received by them. Hence, only the capitalists' propensity to save is relevant in determining the rate of profit necessary to sustain the accumulation process compatible with the natural population growth rate.

As is well known, there are at least two views among post-Keynesians regarding the achievement of the income distribution configuration described by equations (21). Kaldor looks at income distribution identified by equations (21) as a configuration which *tends to be* fulfilled in the long-run thanks to certain additional assumptions on the behaviour of the economic system. On the other hand, Pasinetti is less inclined to look at the income distribution configuration entailed by equations (21) as a situation that the economic system tends to reach in the long run. He prefers to avoid to introduce further specific assumptions on the behaviour of the economic system. Rather, he looks at equations (21) as a necessary condition that has to be satisfied for the economic system to develop along a full employment, balanced growth path, i.e. he attributes a *normative* meaning to conditions (21).

To summarize, we can sketch the *causal* links between growth and income distribution for Classical and post-Keynesian economists as follows: i) for Ricardo

profits *determine* investments; ii) for Kalecki and Kaldor investments *determine* profits in such a way as to generate the level of savings used to finance any given level of investments; iii) Pasinetti limits himself to identifying the *necessary* income distribution configuration to sustain growth along a full employment balanced growth path. Beyond these peculiarities in post-Keynesian view, profits are mainly conceived in connection with their function of being an engine of growth. The remaining part of the social product, wages, can be devoted to workers, *as a residuum* from the social net product.

This view constitutes an alternative to the vision implicit in the neoclassical theory of income distribution, where profits, as well as wages, rents and the price of each good, appear as the result of an interaction of the decisions of *all* individuals, a sort of evaluation *shared*, on average, by all the individuals belonging to a society. The power of determining income distribution is fragmented and widespread among all the members of a society; this sort of 'democratic consent' is supported by the complex web of *interdependences* among individuals typical of any general equilibrium model. On the contrary, in post-Keynesian theories, profits depend on the expenditure decisions of *one* class, that of capitalists; this asymmetric position of capitalists in the accumulation process and the simple *causal* direction entailed by equations (21) displays their primacy in determining accumulation and the process of income distribution; individuals are by no means equal: while workers can earn a part of their income from capital gains and interest rates, their own choices do *not* affect the rate of growth and distribution: only the choices of those people whose income accrue exclusively from capital i.e., the 'pure capitalists', can determine which path the system will take. Neoclassical economists and 'liberal thinkers' like Samuelson and Modigliani could not avoid being utterly provoked by the Cambridge equation and devoted their efforts to denying its validity, or at least, dismissing its relevance. This explains their attempt to try to minimize the range of application of the 'Pasinetti theorem' and their claim in favour of the higher generality of the neoclassical adjustment mechanism embedded in their 'anti-Pasinetti theorem' (see Modigliani and Samuelson, 1966; see the reply by Pasinetti in 1974, VI essay).[26]

7. Final remarks

Pasinetti's 1965 essay *Causalità e interdipendenza nella teoria economica e nell'analisi econometrica* has enabled us to identify the existence of a wide-ranging research programme which can be found in Pasinetti's works. Already in his early writings, fundamental methodological issues were grounding an overall rethinking of modern economics along the lines of the classical-Keynesian approach. The complex relation between causality and interdependence was sorted by Pasinetti as an analytical tool used

[26] There is another critical view of the result entailed by the Cambridge equation, originally developed within the modern Classical reappraisal of political economy by Fernando Vianello (1986 and 1996) and Pierangelo Garegnani (1992). A careful comparison with this literature is beyond the purposes of the present work and will be the subject of future investigation by the authors.

to characterize the nature of the classical-Keynesian approach and emphasize its profound divergences with the marginalist-neoclassical paradigm.

The aim of this paper is to offer a first tentative inquiry into 1) how this research program was routed in Pasinetti's training as an economist and econometrician and 2) how the relationship between causality and interdependence was developed in Pasinetti's main theoretical contributions. In the first section of this paper we basically tackled the first issue, while each of following sections was devoted to the latter.

It is notorious how Pasinetti's research program was the outgrowth of his exposure to the Cambridge (UK) environment of the 1950s and 1960s. Yet, looking at Pasinetti's training during his studies under Siro Lombardini's tutorship at the Catholic University of Milan, we are able to retrace quite a deep connection between the debates over econometrics in the 1950s and his later reflections on the nature of the conflict opposing modern Walrasian economics and the Classical-Keynesian approach.

This conflict, as expounded by Pasinetti ever since his 1965 essay, can be read in light of the relationship between causality and interdependence in economic theory. Three main points can be identified on this matter. First, causality has to be understood within Herbert Simon's methodological proposals, i.e. not as a deterministic description of how reality actually is, but as a formal property of the model used to understand it: more specifically, a causal order emerges when a system of equations is asymmetric in nature, since it contains some equations that can (and must) be solved first and independently of the others, while the latter can be solved only once all the former equations have been solved. Second, discovering and exploring the fundamental causal chains beneath the surface of economic phenomena throws a bridge between the classical and the Keynesian economic approach, which distinguishes them from the neoclassical approach. Third, in the 1965 essay the difference between causality and interdependence parallels with the distinction between two levels of analysis that will later become the object of Pasinetti's 'separation theorem' (separation between a purely economic-technical sphere and an institutional sphere). Pasinetti clearly points out that, while causality and interdependence can be helpful in understanding single economic contexts and phenomena, the "normative" or "potential" level of analysis (later referred to as the "natural system") is the domain of causal relations only. The parallel between these classifications is not fully convincing (not all relations in the natural system are of the causal type, not all relations in the institutional system are of the interdependent type); in subsequent writings, Pasinetti no longer underlines a connection between these two methodological perspectives. It is our opinion that, in his later theoretical contributions, Pasinetti consistently pursues the discovery of Simon-causal type of relations, which he sorts as a primary target of his efforts as an economist (and, incidentally, it is probably one of the reasons why he never pursued his initial econometric background). We have tried, here, to follow him in his longstanding intellectual journey and verify how the notion of Simon-causality became one of the main building blocks of his theory.

This interpretative effort has allowed us to clarify a few critical points on how Pasinetti's thought took shape and suggests some possibilities of why it did. As a first step, in reviewing the debate over Pasinetti's 1960 formulation of the Ricardian system, we observed how his interpretation was not immune to criticism. Pasinetti's claim of a strictly causal chain in Ricardo's theory of income distribution was in fact challenged by Costa, who emphasized how in Pasinetti's formulation final demand was simultaneously determined with the distributive variables of the model, inducing thus full interdependence among all the variables of the system. There is, however, a way to overcome Costa's argument: that of assuming given quantities of the output of the two commodities in line with the methodology used in the 'surplus approach'.

Another point of discussion arises with Pasinetti's presentation of Keynes's principle of effective demand: effective demand represents, in his view, another fundamental causal chain running from the rate of interest to income via investment decisions and the multiplier. This result crucially depends on Pasinetti's specification of Keynes liquidity preference curve, which differs from the specification proposed in the IS-LM model: the latter entails a full-interdependent determination of consumption, savings and the rate of interest. A subtle argument is that also Keynes's liquidity preference is such to entail full interdependence among variables. Yet, we have argued that Pasinetti's formulation closely follows Keynes own view on the subject, as is seen in his post-*General Theory* discussions with Robertson and Ohlin, on the purely monetary nature of the rate of interest, whose level is neither affected by consumption and saving decisions nor by the level of income. We have also provided analytical support for this.

We have also examined how causality and interdependence entered the Pasinetti framework of structural change. A first focal point is Pasinetti's attempt to overcome the straitjacket of structural interdependencies *à la* Leontief, from which he patently drew inspiration but in which only a uniform growth of the system could occur. An analysis of structural change (i.e. a non-proportional growth of the various sectors of the economy) requires instead that the interdependence between sectors are cut off in favour of a causal chain running along intra-sectoral changes. The entire system appears as subdivided in sectors (one for each final commodity) operating in parallel of one another: *technical* interdependences appear thus hidden by the device to represent the productive processes in vertically integrated terms. The Keynesian root of this framework establishes a Simon-causal relationship between final demand and the outputs of the various commodities; in the same way, the Classical root establishes a Simon-causal relationship between the labour content of commodities and their prices.

Pasinetti's choice to let the expansion of any sector be driven by an *exogenous* rate of growth in the final demand and an *exogenous* rate of change of technical coefficients avoids any sort of co-determination between prices and quantities which is at the basis of the theory of prices and of income distribution based on supply and demand curves. While the prices of commodities are determined by their expenses of production, the reward of the factors of production remains under the domain of the

institutional setting of a given society. It is true that an overall interdependence among all sectors reappears with the 'macro-economic condition', which relates the aggregate employment level to the level of expenditure of individual incomes (wages plus profits). Yet, this kind of interdependence is of a completely different nature from the one implied by the Walrasian general equilibrium theory. No automatic mechanism takes care of the fulfillment of the above condition: the interaction of (private and public) institutions will determine the final outcome in terms of income distribution, level of economic activity, and employment.

Finally, Cambridge post-Keynesian theories of income distribution are read under the perspective of providing an asymmetric and causal explanation of profits and wages alternative to their co-determination entailed by the demand and supply approach extended to the 'market' of productive factors.

Regarding Pasinetti's notion of causality, it can be defined as a procedure by which complex economic processes may be decomposed and examined in a logical order. The aim of Pasinetti's investigation is to give priority to the human content of all economic processes and highlight the wide space of freedom (and common responsibility) that human societies have in determining their final outcomes.

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