

Probabilistic Adjustment Process Model in the Reproduction System and The Market Vision : Classical Long-Period Positions Revisited

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1. Introduction

Conventionally, Long-Period Positions (LPPs) in the classical school, like Smith (1789), Ricardo (1819), Marx (1867), Sraffa (1960), is regarded as the stability of *given* LPPs, because data changes are made harmless, only if these are *sufficiently slow*, compared to the speed of convergence of short-period magnitudes. Therefore, some persistence (chronological and theoretical) is required. However, stability has little or no place within the long-period framework, and if some persistence doesn't exist, new (different) data would lead to new different values for the endogenous variables, and these would not depict a long-period equilibrium. Especially, capital endowments in Walrasian, and produced quantities in Sraffian are the problems with which it should be dealing. These models don't hold the inner logic that determines these: interaction between endogenous and exogenous variables.

It is, however, commonly considered that the outcome at a micro level and a macro level is in a looped relationship. The amount of aggregate demand as the result of consumers' decision-making is contained in the determination factor of the amount of aggregate supply. Furthermore, the amount of commodities demanded depends also on outputs as a result of producers' *decision-making*, prices and distributions. In other words, *decision-making* at a micro level plays important roles, and different adjustment paths may offer different rest points (LPPs): LPPs may become *path dependent*. Or rather, LPPs may not rest in a conventional meaning.

Garegnani (1990, p.123) defines 'two fields' of analysis. Firstly, what is so-called classical 'core' by him is the precise quantitative relationships between w , P and r ¹ (the other magnitudes being held fixed); in other words, the relationships which are the main focus of *Production of Commodities by Means of Commodities. Prelude to a Critique of Economic Theory* (Sraffa, 1960).

“These relations have to be studied on the basis of given methods of production and, therefore, on the basis of given level of output when return to scale are not constant” (Garegnani, *op.cit.*, p.124).

¹ Wage rate, price and rate of profit are represented by w , p and r respectively.

A second field of analysis is related to outside the 'core'. Outside the 'core' are the analyses of the relations between the data, and of the reverse effects of 'surplus shares other than wages' and P on these data. For classical economists, a separation of analyses would be needed if there is a change in technical conditions, and technical progress. This is so because they can compare among some achieved different systems. However, this separation of analyses may appear to imply a weakness of the classical method when compared to the single, all-embracing approach of neoclassical general equilibrium theory, since, compared to the classical economists' age, the changes in the situation are remarkable in the present age, and hence there is no guarantee that the natural price (center of gravity) keeps staying and/or the position as the norm. Then, how should this separation be evaded or integrated?

Therefore, the purposes of this paper are (1) to reconsider LPPs, (2) to extend the notion, (3) to offer the adjustment process model view that a market is cleared and social stationary state can be maintained, even if there are the influences from the outside the 'core', and (4) to evaluate the model.

2. Reconsideration of Long-Period Positions and Beyond

2-1. The Notion of Long-Period Positions

According to Sraffians, the classical and early neoclassical economists (particularly Walras) analyzed economic reality by studying and comparing LPPs. There are various arguments over the definition or validity of the notion of Long-Period Analysis (see Garegnani 1976, Camitani 1990, Boggio 1990, Salanti 1990, Roncaglia 1990) and usually, the notion of LPPs in the classical school is considered as follows (Salanti 1990, p.96):

- (i) The classical notion of competition rests on the existence of a mechanism (capital mobility between different "industries") which drives the system towards the general establishment of a uniform rate of profit.
- (ii) Natural prices (that is those prices corresponding, among other things, to a situation of uniform rate of profits) are "centers of gravitation" for market prices which may happen to be lower (higher) than the former whenever the quantity supplied to the market is greater (smaller) than the "effectual demand" as defined by Adam Smith².
- (iii) The rationale of focusing attention on natural prices is provided by the assumption that the forces which determine them are the more systematic and persistent and therefore, in the long-run, dominate the transitory and unsystematic ones (that is, those responsible for the fluctuations of market prices around their "centers of gravitation").
- (iv) The method of LPP (that is the notion of a long-run equilibrium as a sort of benchmark for the actual state of economy) was not peculiar to classical political economy, but was also employed by neoclassical economists such as Walras, Marshall, Wicksell and so on until the 1940's.
- (v) Subsequently, following Hicks's seminal work on general equilibrium, the neo-Walrasian approach

² "the demand of those who are willing to pay the natural price of commodity, or the whole value of the rent, labour, and profit, which must be paid in order to bring it thither" (Smith, p.56).

abandoned the method of LPP and progressively focused on temporary equilibria: in doing so, however, this approach would have lost any relevance precisely because it must rely upon “data”, including “the state(s) of nature” and “expected prices”, which cannot be assumed to remain constant long enough to allow the economy to reach a meaningful position of equilibrium.

Classical LPPs are defined as a given productive technique, a given state of distribution (e.g., a given real wage rate), a set of given outputs and an associated set of relative commodity prices (natural prices). Price determination makes no reference to price elastic demand functions of consumers, but is based on a set of given outputs with the use of the given technical conditions and the exogenous determination of a distributive variable. To interpret the gravitation hypothesis approvingly leads quite naturally to consider the LPPs as the rest point of a dynamic adjustment process starting from arbitrary conditions, because market prices move around natural prices.

How does a specification of the adjustment process entail a specification of long-period output growth? In so far as the stability of an LPP is posed as a problem of the stability of a rest point, long-period accumulation must be identified with *balanced growth*. By Camitani (*op.cit.*, p.14), “This is quite obvious, since the adjustment process to an LPP involves changes in quantities (beside prices), and, by definition, the rest point of adjustment process is stationary (time invariant), under the forces which drive the adjustment.” When the vector of long-period quantities is allowed to change, we must limit the changes only up to a multiplicative scalar, which identifies the rate of balanced growth. This fact carries out the implications of the two phases. The first is that “the stability of LPPs would be more correctly posed as a problem of path stability, where short-period magnitudes adjust towards a moving position” (*ibid.*, p.16). The second is that “balanced growth can be regarded as a first-step approximation; this would be legitimate only to the extent that changes in long-period *proportions* are sufficiently slow, if compared to the speed of convergence of short-period magnitudes” (*ibid.*, p.16).

In ways of approaching the overall issue of stability of LPPs, this type of stability of LPPs is regarded as the stability of *given* LPPs (see Arena and Torre, 1986). It is also possible to change in long-period magnitudes (the methods of production with use at the long-period outputs and the real wage), but, as mentioned above, those changes are made harmless, only if they are *sufficiently slow*, compared to the speed of convergence of short-period magnitudes.

2-2. Terminological Note —chronological persistence and theoretical persistence

There are many researchers who have studied classical economics and/or LPPs, but it is difficult to say that a methodological and, in a sense, ‘essential’ approved condition of LPPs has been clearly described. Of course, the viable condition of the system (or society) has been discussed, but ‘essential’ things meant here are the preconditions and subjects of research, in the study of LPPs. Recently, D’Orlando (D’Orlando 2005, 2006; D’Orlando and Nisticò 2006) is contributing to these areas. Firstly, he points out the importance of terminological distinction over the research of LPPs.

“Different scholars give different names to the same concept or give the same name to different concepts. [...] No clear distinction is made between convergence and gravitation or convergence and *stability or convergence*” (D’Orlando 2006, p.1).

According to him, the differences between convergence and gravitation are the result of differences of the way of movements about actual magnitudes (market prices). Namely, if they obediently can leave for LPPs, the movement would be called a convergence. On the other hand, if they oscillate constantly around LPPs, the oscillation may be called gravitation. Hence, before the convergence, the system is in temporary disequilibrium:

“[...] the sectoral distribution of installed productive capacity is not the equilibrium distribution, i.e. current productive capacity cannot produce quantities that match the quantities of effectual demand, which would be demanded at natural prices” (*ibid.*, pp.3-4).

It is natural that the rate of profit is also lopsided, so if capital movement is not obstructed, it might be equalized. Furthermore, actual *average* market prices are not equal to natural prices, but if the convergence can be achieved completely, the deviation would vanish. On the contrary, the oscillation must not occur, if the system is not in ‘almost equilibrium’, in other words, the convergence cannot be achieved. This is so because the oscillation would occur around the center of gravity (LPPs) and the market price would not oscillate in a place too far from the equilibrium point. However, it is necessary to pay attention to the following facts:

“In these circumstances [after the convergence], market prices still differ from natural prices because of random disturbances in demand and supply” (*ibid.*, p.4).

A certain condition is necessary so that the coincidence between the average market price and the natural price may keep continuing, but this point will be described later.

The relation between the convergence and the gravitation is as mentioned above. On the contrary, the differences between convergence and stability are the differences that move toward the counterpart. While, in the case of the convergence, *actual* magnitudes (market prices) move toward natural prices, in the case of stability the things moving toward a fixed point are *theoretical* magnitudes determined theoretically by a dynamic model.³ Nevertheless,

“Notwithstanding the crucial difference between the two concepts, convergence and stability are

³ “A system is *stable* if, when perturbed slightly from its equilibrium state, all subsequent motions remain in a correspondingly small neighborhood of the equilibrium. If, in addition to being stable, every motion starting sufficiently near the equilibrium point converges to it as $t \rightarrow \infty$, then the equilibrium is *asymptotically stable*. These are *local* concepts (also called ‘in the small’); if stability is independent of the distance of the initial state from the equilibrium point, we have (*asymptotic stability in the large* (or *global*))” (Gandolfo 1987, p.461);

“A distinction used in economics is that between *static* and *dynamic* stability. Static stability only tells us whether the economic forces that act on the system tend to make it move towards the equilibrium point, but does not tell us anything about the actual path of the system nor whether the system converges over time to equilibrium point. Therefore, the study of static stability is not sufficient, and it is necessary to study dynamic stability: the latter, being based on functional equations, can solve the problems left unsolved by the former” (*ibid.*, p.462).

often used as synonymous also by scholars sharing the long-period method of analysis. A number of studies claiming to focus on convergence (gravitation) actually deal with stability” (D’Orlando 2006, p.5).⁴

When the difference between the convergence and the stability is taken into consideration, a sequence of equilibria is incompatible with the logical foundations of the long-period method. This is so because

“[...] no theory can exactly determine the actual values of economic variable. [...] changes in (temporary) equilibria which constitute the single steps of the dynamic process are too fast for (convergence and) gravitation to take place” (*ibid.*, p.5).

Hence, in terms of the holding reality, LPPs, which the holding reality is achieved if the actual magnitudes can converge to theoretical magnitudes, is more persuasive than a sequence of equilibria.

However, it’s this kind of achievement of a convergence that brings forth another problem. This is because if the convergence is not achieved, the method of LPPs would have no reality and its explanatory power would disappear. As described in this section opening, ‘essential’ preconditions must be required in classical economics. These are now called some persistence by scholars researching LPPs (see Garegnani 1976; D’Orlando 2005, 2006; D’Orlando and Nisticò 2006). Two types of persistence are imaginable: one is *chronological* persistence, and another is *theoretical* persistence. These are not such a new issue in discussion of classical economics but have been an issue existing for a long time. For example, these express the prerequisites such as so-called ‘equalization of the rate of profit’ and ‘repetition of market condition.’

According to the definition of D’Orlando et al., *chronological* persistence is related to the character of economic system, and

“We have chronological persistence when the forces that determine the long-period position persist long enough for market prices to complete the process of convergence” (D’Orlando 2006, p.6).

This persistence corresponds to the ‘the repetition of market condition.’ In the absence of it, the center of gravity (natural prices) which is determined theoretically would change and/or move because of the absence of the time which the deviation between theoretical magnitudes and actual magnitudes is adjusted. Therefore, the method of LPPs would not keep holding reality in this case, because it is important for classical economics that actual magnitudes correspond to theoretical magnitudes.

The other persistence is *theoretical* persistence, and it is related to the economic model itself for the explanation of the reality. This is represented by ‘the equalization of the rate of profit’ in the classical economics.

⁴ For example, Parrinello (2006); Harris (2000); Hosoda (1985).

“[...] the theoretically determined values of the endogenous variables should be such not to induce any change in the values of the data used to determine them. Otherwise new (different) data would lead to new (different) values for the endogenous variables. As a consequence the model would not provide a theoretically stationary solution, but only a temporary equilibrium solution. Such an equilibrium changes through ‘theoretical time’” (D’Orlando and Nisticò 2006, p.4).

Hence, ‘such an equilibrium’ (Walrasian type) is not a center of gravity (the fixed LPPs by chronological persistence).

While the above-mentioned points have been controversial things for long time, the proposition of D’Orlando and Nisticò is more advanced. To sum up their logic briefly, Sraffa’s output is considered as given and reflects the market demand. Hence, the output is ‘a right value’ in the sense that the quantities of demand are produced completely. If it is not ‘a right value,’ Sraffian prices cannot clear the market and the rate of profit may not be equalized among the sectors. To determine the right value, short-period analysis is necessary within the conventional Sraffian framework.

2-3. The Other type of Long-Period Analysis

Classical LPPs are defined as a given productive technique, a given state of distribution, a set of given outputs and an associated set of relative commodity prices (natural prices). This fact is justified by the reason that in the economic systems actually observed by classical economists, ‘data’ changed much less quickly than now. Sraffa’s given quantities are a formalization of *effectual demand* and “may be interpreted as referring to the outcome of the production process which the entrepreneurs consider to correspond to a normal degree of capacity utilization” (Roncaglia *op.cit.*, p.109). Hence, the produced quantities must be the right value corresponding to the effectual demand. Otherwise, the sale of these commodities at Sraffa’s prices would not clear the markets and the tendency of the rate of profit to equalize not would be realized. However, how are these adjusted to the right value? Are changes slow enough?

In today’s economic environment, a system sets a stationary state as the foundation rather than equilibrium in neoclassical theory: though it has fluctuation, a system may be reproduced, and it does not need to be considered as restricting the speed of changes. Or rather, just changes are important, and diversity and natural selection stimulate various technical progress or development of an economy. In spite of the diversity of changes, a system is maintained. This notion is conflicting with a conventional long-period equilibrium theory because it can’t treat the more complex issue concerning the formation of LPPs: the process of changes and adjustment process are not explained in full detail. Therefore, if these points are improved, classical theory can ensure consistency with the modern economies.

It is considered that there are two types as for the source of changes. A first is related to the influence of factors such as endogenous technical progress and decision processes of agents. Since there are processes of learning by experience, which tend to establish a link between the level of outputs and the improvement of best practice techniques, different adjustment paths may offer different rest points (LPPs): LPPs may become *path dependent* (see Camitani 1990). For this reason, the classical notion of competition needs an explanation involving *intentional behavior* from capitalists, furthermore, one from

consumer's also. A second is identified in the possible dynamic interactions among long-period magnitudes. An exogenous change in one long-period through one or more of the adjustment reactions magnitude may trigger changes in other long-period magnitudes. Mainwaring (1990) has considered a change of the normal real wage, via modified demand conditions, that affects normal outputs and method of production. According to him, the influences arise from endogenous technical progress; from the fact that modified demand conditions give rise to different fluctuations of outputs, hence, to a different desired ratio of capacity utilization (or of inventories to outputs).

If these types of LPPs analysis are admitted, gravitation can't be considered as a process that market prices move around natural prices with given magnitudes. The process which determines given data must be described because given magnitudes are determined independently of the gravitation process itself. Therefore, a theoretical investigation about LPPs must progress to the following step of how given magnitudes are determined: the short-period adjustments process. Garegnani (1983, p.309) states that "the 'natural' or 'normal' price [...] is the only one that we may expect to experience under the non-accidental conditions that are likely to emerge through a repetition of the situation". When data on which agents must rely for taking decisions are continuously changing the meaning of the expression, a repetition of the situation becomes obscure. The existence of "data" changes implies that expectations play an important role and only *the sequential method* (not conventional method of long-period equilibrium) can deal with this problem.

"[...] the long period method of analysis [...] attempts to represent states of the economy which have the role of centers of gravitation of observed day-to-day magnitudes: chance movements away from such a state set off forces tending to bring the economy back to it. Changes in the economy can then be studied by comparing the long-period positions corresponding to the situation before and after the change. Post-Walrasian equilibrium cannot have such a role, because they rely on data some of which (the endowments of capital goods and, where futures markets are not complete, expectations) would be altered by any chance deviation from the equilibrium: thus the forces set off by this deviation would not tend to bring the economy back to the same equilibrium" (Panico and Petri 1987, p.240).

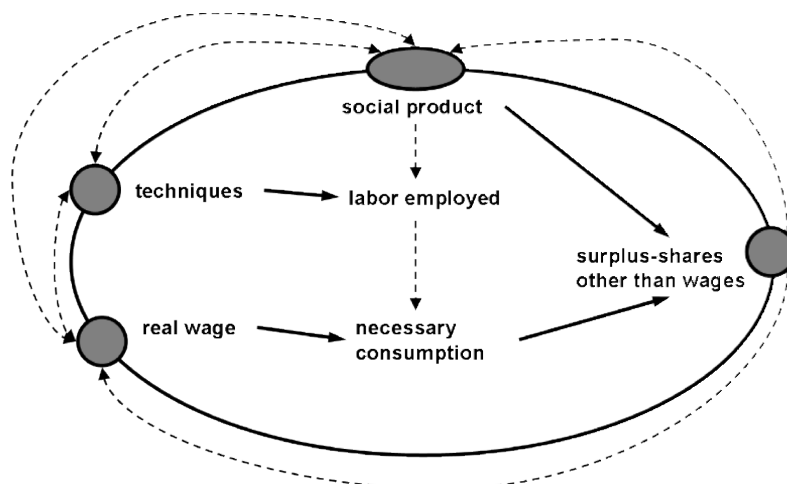
3. 'Iterative' Procedure

Garegnani defines 'two fields' of analysis. Firstly, what is so-called classical 'core' by him is the precise quantitative relationships between w , P and r .

"These relations have to be studied on the basis of given methods of production and, therefore, on the basis of given level of output when return to scale are not constant" (Garegnani 1990, p.124).

Outside the 'core' are the analyses of the relations between the data, and of the reverse effects of 'surplus shares other than wages' and P on these data.

The ‘core’ in the classical theory by Garegnani (1990)



“In this second field all those dependencies could be studied together with all the other factors influencing wage, the social product and technology – like social and political factors, independent monetary factors, or independent technical changes. The multiplicity of these dependencies, and their variability according circumstances, made it necessary [for the classical economists] to study them *separately* from the relations of the core and not *simultaneously* with them” (*ibid*, p.125);

“The demand and supply explanation of distribution [...] is founded on a belief in the possibility of extending the field of necessary quantitative relations of sufficiently define general properties *beyond* those between distributive variables and prices which we find in the ‘core’ of classical theory. [...] relations between prices and the quantities demanded of commodities, taken jointly with analogous necessary relations following from the existence of alternative methods of production, were seen to entail the existence of decreasing demand functions, which provided the basis for a determination of both the wage and the quantities produced, and thus of most economic phenomena, by ‘demand and supply’” (*ibid*, p.125).

For classical economists, a separation of analyses would be needed if there were a change in technical conditions, and a technical progress. This is so because they can be compared with some achieved different systems. However, this separation of analyses may appear to imply a weakness in the classical method when compared to the single, all-embracing approach of neoclassical general equilibrium theory, since, compared to the classical economists’ age, the changes in the situation are remarkable at the present age, and hence there is no guarantee that the natural price (center of gravity) keeps staying and/or the position as the norm. Then, how should this separation be evaded or integrated? About this issue, Garegnani himself offers a provisional solution.

“[...] the absence of theoretical criteria, capable of identifying equilibrium quantities, forces Sraffians into ‘ex post accounting problem’” (D’Orlando 2005, p.642);

“If an exogenous shock changes the ‘old’ equilibrium quantities, Sraffians can only identify the ‘new’ quantities (and hence the new long-period position)” (*ibid.*, p.643).

Garegnani (1990) attempts to determine these new quantities ‘ex ante’ by the method of iterative procedure. His procedure is made up of two logical steps, but because his explanation is a little complex, accepting to D’Orlando’s interpretation (see D’Orlando 2005, p.644) is the best way to understand Garegnani’s idea easily. Because his formulation abstracts the effect on outputs by changes in distributive variables, it is necessary to pay attention to the elimination. However, it is enough in D’Orlando’s formulation to understand the essence of Garegnani’s idea.

It is assumed that, q_t^D indicates the quantities demanded at time t as a function of the prices p_t ; q_t^0 indicates the quantities produced at time t , which are equal to the quantities demanded at time $t - 1$; p_t indicates the prices at time t , as computed using the technical coefficients (A_t and l_t) necessary to produce q_t^0 . And then;

$$q_t^D = f(p_t) ; \tag{3.1}$$

$$q_t^0 = q_{t-1}^D ; \tag{3.2}$$

$$A_t = g(q_t^0) ; \tag{3.3}$$

$$l_t = h(q_t^0) ; \tag{3.4}$$

$$p_t = A_t p_t (1 + r) + l_t w . \tag{3.5}$$

In the long-period position,

$$q_t^D(p_t) = q_t^0 . \tag{3.6}$$

If it is easily summarized, it would be as follows. The quantity of output in the period t is determined by the quantity of demand in the period $t-1$, under the condition that agents refer to the prices in the period $t-1$. If entrepreneurs determine the quantity of output in period t , technique and labor requirement are determined respectively. Then, the prices in the period t are determined. Namely, the prices depend on past consumers’ demand explicitly. However, these are not long-period positions: Sraffian prices. Though the length of the period is not specified and/or defined in this case, the procedure that an entrepreneur manages to grasp a consumers’ demand and make a production plan is repeated, and finally, the adjusted prices become the production price.

However, D’Orlando points out some problems, especially, he criticizes Equation (3.1):

“[...] if it is impossible to formulize the relationship between prices and quantities – that is, if there is no equation equivalent to Equation (2) – it is impossible to formulize single steps of the iteration. In these circumstances, it is impossible even to *attempt* to prove the convergence of dynamics toward a fixed point. And, if the iteration does not converge to a fixed point, it is useless

for finding a new long-period position after a shock” (*ibid*, p.644, Equation (2) means Equation (3.1) in this case);

“Given that the steps in the iterative process do not describe the actual behavior of markets and that the prices generated by each step cannot be attractors, it is illegitimate to take the quantities required by the iteration from reality, either directly or indirectly. An investigation into the dynamics of the iteration would require *a priori* knowledge of the demand vector corresponding to any possible price vector; in short, it requires a precise relationship between prices and quantities such as relation (2)” (*ibid*, p.645, Equation (2) means Equation (3.1) in this case).

Therefore, in the consideration of separation problems, it is necessary to offer a model of the adjustment process between prices and quantities, in terms of the actual behavior of markets.

4. The Bridge between Long- and Short-period Models

For the purpose of tackling the new type of long-period analysis, Caravale’s three-sectoral model (1994) is applied and extended to multi-sectoral model. The model has five features⁵, as follows (see Caravale 1994, pp.54-56):

- (i) As the main kernel of the analysis of the adjustment process, *expected demand* substitutes for *effectual demand* in Smith and Ricardo. Expected demand is defined as the quantity that each producer expects to be able to sell at the ‘announced price’. Announced price (defined at (iii)) takes up the role previously assigned to the notion of natural price as the main reference point for the adjustment process.
- (ii) Producer’s expectations are influenced by recent experience with regard to comparison between expected and realized profit rates, as well as to the possible divergences among sectoral profit rates.
- (iii) Announced price, that could be thought of as the price each producer ‘marks’ on the commodity ‘exposed’ for sale, is formed on the basis of technology appropriate to the produced quantities, of the real wage rate, and the expected rate of profit. Announced price can change during the adjustment process.
- (iv) The market clearing hypothesis which the model incorporates is not based on neoclassical type demand functions, but on what could be called a Smithian type tâtonnement (not so-called *invisible*

⁵ The features don’t change in the extended model.

⁶ “When the quantity of any commodity which is brought to the market falls short of the effectual demand, all those who are willing to pay ... [the natural price] cannot be supplied with the quantity they want. Rather than want it altogether, some of them will be willing to give more. A competition will immediately begin among them, and the market price will rise more or less ... according as either the greatness of the deficiency, or the wealth and wanton luxury of the competitors happen to animate more or less the eagerness of the competition ... When the quantity brought to market exceeds the effectual demand, it cannot all be sold to those who are willing to pay ... [natural price]. Some part must be sold to those who are willing to pay less, and low price they give for it must reduce the price of the whole. The market price will sink more or less ... according as it happens to be more or less important to them to get immediately rid of the commodity” (Smith, p.57).

hand in neoclassical)⁶ – a *sequential* process related to a commonsense empirical regularity. “The market clearing mechanism is to be thought of as ‘internal’ to what can be called the market period – that goes from the moment produced commodities are offered in the market to the moment in which the decisions are made as to the following logical phase. It is in this period in fact that the market clearing mechanism allows the determination of the actual rate of profit earned in each sector, which constitutes one of the main reference points for the decisions to be made at the beginning of the following logical phase” (Caravale 1994, p.55).

- (v) Two assumptions are made. Although non-constant returns to scale are allowed for, quantity adjustments on the part of producers do not imply violent changes in technical coefficients. Producers can – on the basis of the actual outcomes of preceding moves – change their decisions as to the quantities produced, but the change in these quantities and the associated changes in the technical coefficients will not be dramatic.

(1) Quantity equations relate to the quantities that producers decide to bring to the market.

$$q_{i(n)} = \varepsilon_{i(n)} \mu_{i(n)} v_{i(n)} q_{i(n-1)} \quad (4.1)$$

with

$$\begin{aligned} \mu_{i(n)} &= \mu_{i(n)}(\Pi_{i(n-1)}, \pi_{i(n-1)}) \text{ such that } \mu_{i(n)} \begin{cases} \geq 1 & \text{if } \Pi_i \geq \pi_i \\ < 1 & \text{if } \Pi_i < \pi_i \end{cases} \\ v_{i(n)} &= v_{i(n)}(\Pi_{i(n-1)}, \Pi_{\rho,i(n-1)}) \text{ such that } v_{i(n)} \begin{cases} \geq 1 & \text{if } \Pi_i \geq \Pi_{\rho,i} \\ < 1 & \text{if } \Pi_i < \Pi_{\rho,i} \end{cases} \\ \varepsilon_{i(n)} &= 1 + \varepsilon_{i(0)} |1 - \mu_{i(n)}| |1 - v_{i(n)}| \end{aligned}$$

and

$$\Pi_{i(n)} = \frac{P_{i(n)}}{\sum_{j=1}^m a_{ij} P_{j(n-1)}} - 1 \quad (4.2)$$

$$\Pi_{\rho,i(n)} = \sum_{i=1}^m \left(\frac{Q_i}{\sum_{i=1}^m Q_i} \Pi_{i(n)} \right) - \frac{Q_i}{\sum_{i=1}^m Q_i} \Pi_{i(n)} \quad (4.3)$$

$$Q_i = q_i P_i \quad (4.4)$$

where⁷

$n = 1, 2, \dots$ indicates the logical phase of the adjustment process;

$i, j = 1, 2, \dots, m$ indicates the sectors of production (m sectors);

q_i is the quantity produced in the i -th sector;

π_i is the rate of profit expected in the i -th sector;

Π_i is the rate of profit realized in the i -th sector;

$\Pi_{\rho,i}$ is the rate of profit realized on average in the rest of the economic system;

⁷ Caravale's notations and definitions are basically adopted.

μ_i indicates the correction factor based on possible divergencies between the realized and the expected rate of profit in the i -th sector;

ν_i indicates the correction factor based on possible divergencies between the realized rate of profit in the i -th sector and the rate of profit realized on average in the rest of economy;

ϵ_i indicates the state expectations. $\epsilon_{i(0)}$ forms an essential part of the fundamental data concurring to define the equilibrium position which represents the central reference point of potential convergence process; it express on one hand past experience concerning compatible levels of price and quantities and on the other hand, expectations of possible changes in demand.

(2) Announced price equations relate to the prices at which these quantities will be offered for sale.

$$pa_{i(n)} = \left[\sum_{j=1}^m a_{ij} P_{j(n-1)} \right] (1 + \pi_{i(n)}) \quad (4.5)$$

with

$$\pi_{i(n)} = \pi_{i(n-1)} \frac{\mu_{i(n)}}{\nu_{i(n)}} \quad (4.6)$$

where

pa_i is the announced price in the i -th sector.

(3) Market price equations (and the market clearing mechanism) relate to the market prices that the market will determine when the quantity demanded at the announced price is different from the quantity brought to the market.

$$ptm_{i(l)} = z_{ij} (\bullet) ptm_{i(l-1)} \quad (4.7)$$

with

$$ptm_{i(0)} = pa_i \quad (4.8)$$

$$z_{ij} (\bullet) = \left(\frac{\gamma + qd_{i1(l-1)}}{\gamma + qs_{i1(l-1)}}, \dots, \frac{\gamma + qd_{ij(l-1)}}{\gamma + qs_{ij(l-1)}}, \dots, \frac{\gamma + qd_{im(l-1)}}{\gamma + qs_{im(l-1)}} \right) \\ = \prod_{j=1}^m \frac{\gamma + qd_{ij(l-1)}}{\gamma + qs_{ij(l-1)}} \quad \text{with } i \neq j \quad (4.9)$$

and

$$qd_{ij(l)} = f_{ij} \left(\frac{ptm_{i(l)}}{ptm_{j(l)}} \right) + \theta_{ij} \xi \quad \text{with } i \neq j \quad (4.10)$$

$$qs_{ij(l)} = h_{ij} \left(\frac{ptm_{i(l)}}{ptm_{j(l)}} \right) + \tau_{ij} \xi \quad \text{with } i \neq j \quad (4.11)$$

$$P_i = \sum_{l=1}^g \phi_{i(l)} ptm_{i(l)} \quad (4.12)$$

with

$$\phi_{i(l)} = \sum_{j \neq i} \frac{P_j}{ptm_{j(l)}} \psi_{ij(l)} \quad (4.13)$$

and

$$\psi_{ij(l)} = \frac{q_{ij(l)}}{q_i} \quad (4.14)$$

with

$$q_{ij(l)} = \min \{ qd_{ij(l)}, qs_{ij(l)} \} \quad (4.15)$$

where

ptm_i is the temporary market price in the i -th sector (this can be changed by producers in each subphase l of the market clearing process);

$l=1,2,\dots,g$ indicates a subphase of n (there is a finite set of l for each n); each l generates a set of relative temporary market prices in correspondence with which a portion of commodities brought to the market is actually exchanged. These prices initially don't clear the market, but through successive corrections, the portion of commodities which remains unsold gradually to become nil;

z_{ij} is the function that indicates the correction value which is related to relationship between the producers of other sectors, especially the deviation degree of the amount of demand and supply. In Caravale's three-sectoral model,

$$z_{ij}(\bullet) = \frac{\gamma + qd_{ij(l-1)}}{\gamma + qs_{ij(l-1)}} \frac{\gamma + qd_{ik(l-1)}}{\gamma + qs_{ik(l-1)}} \quad \text{with } i \neq j \neq k .$$

If it is considered a multi-sectoral model,

$$z_{ij}(\bullet) = \prod_{j=1}^m \frac{\gamma + qd_{ij(l-1)}}{\gamma + qs_{ij(l-1)}} \quad \text{with } i \neq j ;$$

γ is a constant greater than zero which express the degree of reluctance of producers to adjust their announced prices;

P_i is the actual market clearing price, which is equal to the weighted average of the temporary market price $ptm_{i(l)}$, with weights $\phi_{i(l)}$ which depend mainly on ψ_{ij} as defined by (4.14) above. These weights depend also on the actual and temporary markets prices of the other commodities. Posing $P_{1(m)}=1$ for each phase n , system of equations (4.11) supplies a solution in the relative prices;

ψ_{ij} is the percentage of the total amount of commodity i (brought to the market for sale) which is bought by sector j in each subphase l ;

q_{ij} are the technical coefficients, that is the quantities of various goods produced in the system, which

are employed for the production of one unit of commodity i .

qd_{ij} is the quantity of commodity i that the producer of commodity j is actually willing to buy from sector i at the relative temporary market price ptm_i/ptm_j in each subphase l ;

qs_{ij} is the quantity that the producer of commodity i is actually willing to offer to the producer of commodity j at the relative temporary market price ptm_i/ptm_j in each subphase l (the quantity actually exchanged is the lesser one between qd and qs);

f_{ij} , h_{ij} express the willingness of each producer to acquire: (i) a volume of inputs capable to allow the realization of a level of production at least equal to that realized in the preceding phase, corrected by the expectation factor $\varepsilon_{i(n)}$; (ii) a quantity initially destined to “consumption” which – on the basis of the results emerging at the end of the phase – can be in part employed as input for production. All these decisions can be carried out only if reasonable assumptions are made as to the “vitality” of the matrix of technological coefficients a_{ij} ;

ζ is a given random Gaussian variable with mean zero and variance one;

θ_{ij} , τ_{ij} indicate suitably chosen deviations.

The initial state of the economic system is defined by $\pi_{i(0)}$, $\varepsilon_{i(0)}$, $P_{i(0)}$ and by the functions $a_{ij}(q_i)$.

5. The Evaluation

5-1. The Model

(1) **Smithian tâtonnement** exists in this model, instead of a Walrasian tâtonnement, and is an essence of this model. It consists of a sequence of logical phase (n), which is a short-term adjusted position and each of them is elaborated by a number of subphase (l). Firstly, producers make a decision about the quantities of commodities that they will bring to the market for sale, by using their past *experiences* and future *expectations*. Secondly, they announced their selling prices⁸ of commodities that are determined on the basis of production costs, past rate of profit, expected rate of profit and disturbance factors. Since the amount of demand is determined based on the price of this phase, the quantity of those commodities is a quantity actually exchanged. Therefore, producers have to grasp the expected consumers’ demand by market research⁹: so expectations have a more important role. If their anticipation is incorrect and the quantity of commodities brought to the market exceeds demand, the initial exchange is performed at the announced price. After that, the exchanges expressed as subphase (l) are continued during the process by which entrepreneurs adjust their prices to clear the market. In this process, a proportion of commodities are sold at a temporary market price that may change at the next subphase: there is a case that commodities are sold at *false* prices. Finally, the process comes to an end when the market is cleared.

Conventional models (especially so-called cross dual models) assume implicitly the existence of a Walrasian auctioneer in short-period equilibria that are based on prices that instantaneously equate demand and supply. Therefore, until the equilibrium price is achieved, there are no transactions: no

⁸ This price may be based on a full cost principle

⁹ See Yoshii (2007).

exchange of commodities at the *false* prices.

(2) A **probabilistic view** is adopted in this model. The quantities exchanged are the result of interaction between supply and demand. However, it doesn't depend on *à la* neoclassical function based on agents' maximizing behavior, or rather, it is probabilistic relation based on a set of given magnitudes perturbed by a Gaussian variable. "If demand and supply are probabilistic magnitudes, the quantities exchanged in each subphase will also be probabilistic. The same applies to ('temporary market') prices in each subphase, whose value will depend on the volumes of supply and demand in the previous subphase and to 'market prices' in each phase" (D'Orlando 2005, p.649). Furthermore, the actual outcome of the economic system appears in fact to be strongly influenced by the producers' expectations and depends on the initial choice made by agents': it may become path dependent.

Conventional LPPs have a reality only if each theoretically determined natural prices correspond to the average of market prices actually realized by market. Therefore, some persistence is a prerequisite: repetition of market conditions that is enough to converge, and uniform rate of profit. In this probabilistic model, however, actual prices may diverge from theoretical predictions. This fact is very important because the model need not to consider *chronological* persistence and *theoretical* persistence. This model "matches reality as long as the realization of the random variable—that is, the observed market price—lies within the range of the disturbance" (D'Orlando 2005, p.649).

"for reasonable behaviour assumptions, the out-of-equilibrium values initially chosen by producers for quantities and prices gradually tend to be revised and induce the system to move in the direction of a natural equilibrium position in which quantities and prices are mutually compatible and correspond to a Sraffa-type solution".

"With their decisions these agents crucially contribute to identify the level of production and employment towards which the system tends to move in each period of time—in the expression of Keynes, the 'long-period employment'". (both Caravale 1994, p.60).

(3) However, it is necessary that some micro-foundations for the non-neoclassical adjustment model are provided. For instance, it must be considered the problems about the adjustments via inventories about the quantity produced and/or brought to the market, consumers' decision-making (expected demand) that entrepreneurs should grasp by market research, technical choice and influences based on the changes of wage rate. Irrespective of these issues, this model has important implications. It has described dynamics with holding reality: no persistence of market conditions, no uniform rate of profit. Adjustment is completed without severe conditions, and though fluctuations occur, a system is maintained. The method of marginalists (deterministic functions based on agents' maximizing behavior) is not used to offer short-period position, but rather, this model can describe the stationary state. Furthermore, it may show the first step which connects a short-period and a long-period. Although LPPs is not defined clearly, they are expressed tacitly because the market is sequentially adjusted reflecting the decisions of agents and continuously cleared and a society continues being maintained or

reproduction. Such a state is just the object of a new long-period analysis.

5-2. The View of Market

It's well-known fact that a short-term market doesn't appear in Sraffian system. However, even if price system is defined as viable conditions, changes in the composition of final demand cause fluctuation of prices, and the natural price is formed after the fluctuation settling. Therefore, followers have argued intensely about the short-term market process (see *Political economy: studies in the surplus approach*, Vol.6, 1990). A target of this discussion is right and wrong about cross dual models that assume a Walrasian tâtonnement implicitly in short-period equilibria (see Shirasugi 2005). Sraffa, however, states in his book as follows,

“Anyone accustomed to think in terms of the equilibrium of demand and supply ...” (Sraffa, *op.cit.*, p.v).

In other words, the manifestation of intention, that he never develops logic by using the method of supply-demand balance, is included in the first sentence. Therefore, if followers conform to Sraffa's viewpoint, they should reject this method with the instrumental and mechanical view of market. Then, what type is the view of market in Caravale's model? Furthermore, how should P_i (the actual market clearing price) be interpreted? Before tackling these subjects, it'll be useful to take up Economic Calculation Controversy (hereinafter ECC).

ECC was a controversy about the possibility of the existence of the socialist planned economy. This controversy, however, dealt with various problems, and these can be roughly divided into two points at issue. First, when it's supposed that a market model can rationally allocate resources in the theory, is rational resource allocation also accomplished in various models of socialist economy? Or is the actual operation also possible? That is to say, by using the general equilibrium theory which describes the rationality of the market economy, as theoretical framework, the possibility and the rationality of the socialist economy were analyzed and evaluated. Barone (1908), Mises (1920) and Lange (1936; 1937) were included in the controversies of this group, and it's said that Lange has brought the primary period of this controversy to an end: when a shadow price in socialist economy is included under consideration, an equilibrium solution in static system is the same formally between a capitalist economy and a socialist economy.

As to the second point, there was a group that a target of controversy was the theoretical framework itself. In other words, this is a controversy about whether general equilibrium theory can describe correctly the *feature* of the market economy, and especially, the notion of rationality was argued. Polanyi (1922), Sweezy (1949), Dobb (1933), Schumpeter (1942), Hayek (1935) and Robins (1932) were included in this group. One of this argument may be useful to evaluate Caravale's model.

5-2-1. Lange's Trial-and-Error Method and View of the Market

Barone insisted that, if it's possible to make simultaneous equation system from which a general equilibrium solution can be derived, it's possible to calculate the price of the capital goods and rational

resource allocation can also be accomplished in socialist economy. Hayek, however, criticized as follows,

“It is now rarely denied that, in a society which is to preserve freedom of choice of consumer and free choice of occupation, central direction of all economic activity present a task which cannot be rationally solved under the complex conditions of modern life” (Hayek, *op.cit.*, p.202);
“humanly impracticable and impossible”(ibid, p.208).

Lange worked just on the problem of this impracticality of central planning. According to him, the following condition is necessary for economic equilibrium established by trial and error on a competitive market¹⁰. (A) all individuals participating in the economic system must attain their maximum positions on the basis of equilibrium prices, and (B) the equilibrium prices are determined by the condition that the demand for each commodity is equal to its supply. He call the first the *subjective* and the latter the *objective* conditions. However, these two conditions do not determine equilibrium unless there is added a third condition which expresses the social organization of the economic system. In this case, this condition states that: (C) the incomes of the consumers are equal to their receipts from selling the services of the productive resources they own.

In a socialist economy¹¹, (A') the decisions of the managers of production are no longer guided by the aim to maximize profit. Instead, there are certain rules¹² imposed on them by the Central Planning Board which aims at satisfying consumers' preferences in the best way possible, and (C') as the productive resources outside of labor are public property, the incomes of the consumers are divorced from the ownership of those resources and the form of condition C' is determined by the principles of income formation adopted. The possibility of determining condition C' in different ways gives a socialist society a considerable freedom in matters of distribution of income. But the necessity of maintaining freedom of the choice of occupation limits the arbitrary use of this freedom, for there must be some connection between the income of a consumer and the services of labor performed by him. It seems, therefore, convenient to regard the income of consumers as being composed of two parts: one part being the receipts for the labor services performed and the other part being a social dividend constituting the individual's share in the income derived from the capital and the natural resources owned by society. We assume that the distribution of the social dividend is based on certain principles, reserving the content of those principles for later discussion. Thus condition C' is determinate and determines the incomes of the consumers in terms of prices of the services of labor and social dividend,

¹⁰ “(1) the number of individuals is so great that no one can influence prices appreciably by varying his demand or supply and, therefore, is forced to regard prices as constant parameters independent of his behaviour; (2) there is free entry into and exodus from each trade or industry” (Lange 1936, p.57).

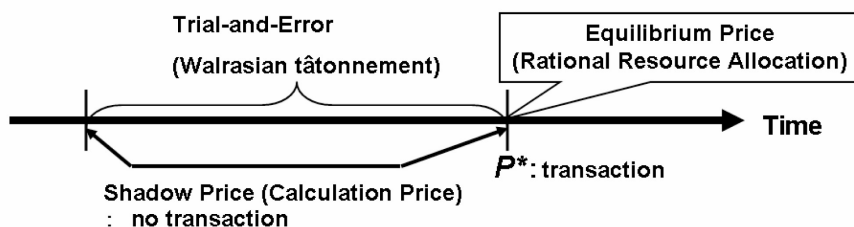
¹¹ “freedom of choice in consumption and freedom of choice of occupation is maintained and that the preferences of consumers, as expressed by their demand prices, are the guiding criteria in production and in the allocation of resources” (*ibid*, p.60).

¹² The managers should adopt a production method that always minimizes the average cost and decide about the output of a plant based on the standard that becomes equivalent in marginal cost and the price of the product.

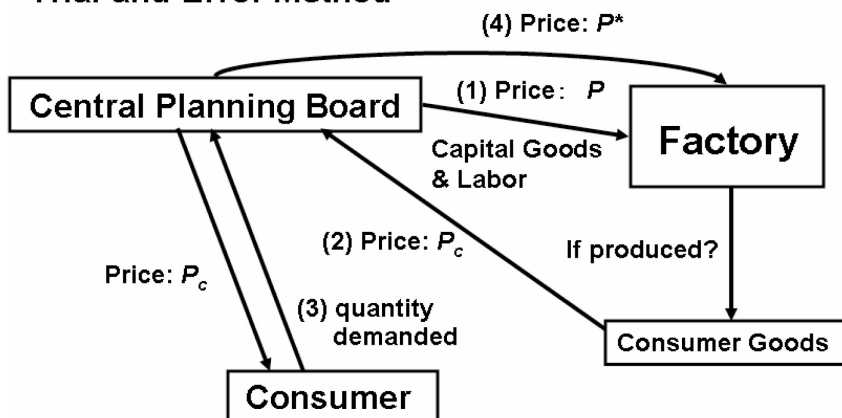
which, in turn, may be regarded as determined by the total yield of capital and of natural resources and by the principles adopted in distributing this yield.

The price of the productive factor and goods is given by the Central Planning Board and the price of consumption goods is calculated by the managers. The Central Planning Board presents the price of consumption goods to consumer, and consumer voice their quantity demanded. Finally, the Central Planning Board revises the price of the productive factor and capital goods. Therefore, that quantity supplied of the productive factor in all industries is decided. Mises criticized that, in the competitive market, agents were price takers and didn't influence prices, but on the other hand, in a socialist economy, prices given by the Central Planning Board were arbitrary. Prices given by the Central Planning Board, however, are the prices announced to managers of each industry first, and managers calculate based on these prices. When announced prices are different from the equilibrium prices, excess or lack of quantity of a certain product is indicated objectively in the adjustment phase. In the case of excess (lack) quantity, the Central Planning Board lowers (raises) the price of the product. An equilibrium solution is achieved by repeating such a process of trial and error.

Lange's View of Market



Trial-and-Error Method



Lange thinks that, when tâtonnement in a market is imitated, it's possible to substitute a plan for the market mechanism, and it's possible for the Central Planning Board to play roles, instead of a market. In other words, he regards a market as the big calculation apparatus given by nature to perform economic calculation. Therefore, the problem achieved at a market can also be achieved by a planned economy.

He insisted in "The computer and the Market" (1967) as follows,

“Let us put the simultaneous equations on an electronic computer and we shall obtain the solution in less than second. The market process with its cumbersome *tâonnements* appears old-fashioned. Indeed, it may be considered as a computing device of the pre-electronic age” (Lange 1967, p.158); “The market mechanism and trial and error procedure proposed in my essay really played the role of a computing device for solving a system of simultaneous equations. The solution was found by a process of iteration which was assumed to be convergent. The iterations were based on a feedback principle operating so as to gradually eliminate deviations from equilibrium. It was envisaged that the process would operate like a servo-mechanism, which, through feedback action, automatically eliminates disturbances” (*ibid*, pp.158-159).

After identifying a computer with a market, he explained advantage of a computer. The computer is admittedly excellent in point of the speed and correctness of the calculation, compared with a market. Lange insisted on the advantage of planned economy to a market economy, because he regarded as "market = nature" and "computer = artificial plan". In terms of this view of market that a market is all-around, however, the problem which achievement is impossible at a market can't also achieve in planned economy. In the end, a market is the instrument to achieve efficient resource allocation.

5-2-2. Hayek's Economic Problems and View of Market

Hayek criticized the socialist economy, and at the same time, pointed out that a distinction between two problems was important. These are (1) technological problem, (2) economic problems. A technical problem is the problem about the way that the only goal (rational resource allocation) is achieved efficiently in the given means, and a general equilibrium theory is the theory which settles this problem. Economic problems are the problems related to economical circumstances where competition always occurs during each economic agent, because even if there is a hierarchical structure about the set of purposes in the economic agents (households and firms), a single hierarchical structure of several purposes in society can't be derived from those, that is to say, it's difficult to synthesize the single objective function from several purposes that economic agents possess. Sen (1982) proved that it's impossible to satisfy the Pareto principle and Minimal Liberty principle (The freedom which should not be interfered with by others' opinion. e.g. how to sleep in a bed) at the same time.

There were three rationales in his criticism. (a) Economic problems aren't considered; (b) it is made impracticable by the limit of the knowledge; (c) a lack of entrepreneur's incentive and self-responsibility can't evade dangerous business and problems related to bureaucracy will occur. Lange settled (b), and (c), it's excluded from consideration because this paper doesn't deal with socialist economy. About (a), however, it is an important issue because it is a criticism about the framework for consideration: a general equilibrium theory itself. Hayek stated as follows,

“In so far as the general question is concerned, however, it is difficult to suppress the suspicion that this particular proposal has been born out of an excessive preoccupation with problems of the pure

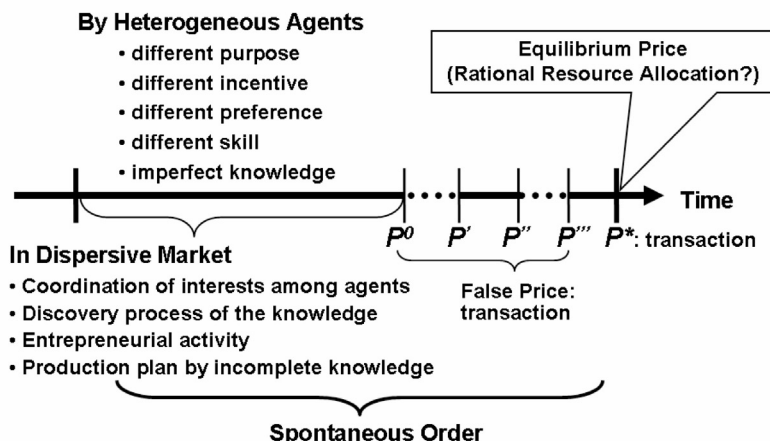
theory stationary equilibrium. If in the real world we had to deal with approximately constant data, that is, if the problem were to find a price system which then could be left more or less unchanged for a long periods, then the proposal under consideration would not be so entirely unreasonable” (Hayek 1948, pp187-188);

“But this is far from being the situation in the real world, where constant change is the rule” (*ibid*, p.188).

The market Lange and a general equilibrium theory assume is the market that is centralized and organized. On the other hand, the market Hayek imagines is a *rivalrous* market. This is a dispersive market in which economic agents compete against each other in terms of their interests, purposes and motivations, and they adjust those. In a dispersive market, all economic agents are coupled loosely, and there is no rationality by which they make their own production or consumption plan to see only a price parameter, but a production, a sales and a consumption plan are made using their restrictive or local knowledge. Each economic agent possesses a different purpose, motivation, preference and technology, and expectation formation is also different. In other words, heterogeneous agents make up a network of the interdependence type¹³. Furthermore, according to Hayek, imperfect knowledge of agents makes progress to more perfect knowledge through a market. Therefore, a market is a place to discover the knowledge. Such market is not the planned market such as in a socialist economy, but the market that spontaneous order is preserved. Spontaneous order is the order that the market kept in integrity at a macro level generated naturally, despite conflict between agents, and in itself, a specific purpose isn't inherent.

Lavoie (1985) recognizes a competition concept of Marx and Hayek as "the one which

Hayek's dynamic market process



equilibrates an uninterrupted dis-equilibrium" that the economic process proceeds with conflict and rivalry. Hayek insisted on the importance of considering the market process, but still recognized the

¹³ Say's law is not true.

existence of the tendency by which a market achieves the equilibrium. However, when his theory is so called dynamics theory, what is the equilibrium that he thought? Is the price, by which efficient distribution of resources is performed, an equilibrium point? Furthermore, why isn't dis-equilibrium process cumulated¹⁴? These problems are still unclear.

5-3. Some Remarks

Comparing the two views of the market above-mentioned (centralized market with Walrasian tâtonnement, and the network which is a dispersive market and agents are combined loosely), how is this probabilistic model interpreted? First, as a structural feature, the phenomenon¹⁵ which can't be assumed under present circumstances is excluded, because there is no Walrasian tâtonnement which adjusts the market, after all information is gathered in one point. So to speak, the point that a possibility of the transaction at the false price is admitted is closer to the view of Hayek. The system, however, in which supply-demand divergence is adjusted by trial-and-error method, and the price is determined sequentially is also similar to Lange's system. In Lange's model, the price during the adjustment process is a shadow price and there is no transaction at that price. On the other hand, there is a transaction at the false price in this probabilistic model. This difference is the difference in system design between rational resource allocation and social reproduction. When rational resource allocation is considered, transaction at the false price isn't admitted because of waste of resources. In Caravale's model, the determined price is not equilibrium price, but market clearing price, in other words, the natural level to which the intentions of those who are willing to pay is adjusted.

Secondly, about the premise of the agents, in the general equilibrium theory, economic agents receive prices as a signal, and their plan of consumption and production is determined by calculating these solutions. Therefore, to create a logical structure, the homogeneity of agents (or preferences) and optimizing behavior should inevitably be assumed. On the other hand, Hayek emphasizes the interest conflicts and imperfect knowledge of agents. However, do agents possess perfect knowledge in a equilibrium point? As a result, are there no conflicts? Or, are the motivation and preference still different among agents? In other words, there is the problem of whether heterogeneous agents will become homogeneous agents or not. Hayek did not comment on this issue.

In a Sraffian system, the macroscopic structure is important and there is no thought that the economy is made by an agent's behavior in bottom-up way. Agents appear in the economical place, and they are the existence who has some role in society. Sraffa (1926), however, stated about entrepreneurial activity as follows,

“Everyday experience shows that a very large number of undertakings-and the majority of those which produce manufactured consumers' goods-work under conditions of individual diminishing costs. Almost any producer of such goods, if he could rely upon the market in which he sells his products being prepared to take any quantity of them from him at the current price, without any

¹⁴ The buffers, such as inventory and faith money, are necessary to avoid the depression.

¹⁵ There is no transaction until the equilibrium price is determined.

trouble on his part except that of producing them, would extend his business enormously. It is not easy, in times of normal activity, to find an undertaking which systematically restricts its own production to an amount less than that which it could sell at the current price, and which is at the same time prevented by competition from exceeding that price. Business men, who regard themselves as being subject to competitive conditions, would consider absurd the assertion that the limit to their production is to be found in the internal conditions of production in their firm, which do not permit of the production of a greater quantity without an increase in cost. The chief obstacle against which they have to contend when they want gradually to increase their production does not lie in the cost of production-which, indeed, generally favours them in that direction-but in the difficulty of selling the larger quantity of goods without reducing the price, or without having to face increased marketing expenses” (Sraffa 1926, p.543).

Shiozawa (1990) pays attention to this issue, and states that, “A basic principle of the subjective equilibrium, which 'in the internal condition of the production of an enterprise, there is something which determines the marginality of the production', is refused clearly.” (Shiozawa 1990, p.144), “When entrepreneurs try to expand the profit, the main obstacle for them isn't a rise of the production cost, but the sales potential” (*ibid*, p.144) and “The sales potential of the product which is the voiced amount from a market, and an enterprise has to pay a special expense to change this. Sraffa called this ‘marketing expenses’” (*ibid*, p.145). More specifically, an enterprise determines output according to the voiced quantity demanded or estimated, and the sales potential fluctuates by advertisement and service to a customer.

In this probabilistic model, the output (the commodities amount taken to a market) is produced, based on the output of the past (the commodities amount taken to a market in the past), the rate of profit expected, the rate of profit realized, the rate of profit realized on average in the rest of the economic system and the expectation state, and the output is influenced clearly by the market trend: under the restrictions of the probabilistic sales potential. In that sense, production activities aren't based on only the internal conditions of the production of an enterprise. When commodities aren't sold-out in a market at the announced price, adjustments are executed. Therefore, sales potentials and market research are important factors in the production activities. If agents have perfect knowledge, there is no divergence of demand and supply. Therefore, imperfect knowledge is admitted in this model. If agents have perfect knowledge, there is no divergence of demand and supply. Therefore, imperfect knowledge is admitted implicitly in this model and this is expressed as ϵ_i that will be being improved through the market process. The concept of perfect knowledge, however, may not be included because probabilistic factors are introduced in the adjustment process, and fallibility exists. It would be assumed that agents are heterogeneous and have limited knowledge.

“The principle of Sraffa”¹⁶ that the basic factor which determines the marginality of the production is the demand voiced to the enterprise brings a fundamental change to the view of market, because a market appears, not as the place where only the price is made an indicator, but as the process with the

¹⁶ Cf. Shiozawa 1990.

history: a general idea of the demand function and the supply function which react only to the price is denied. Furthermore, it is natural that Lange's instrumentalism about the view of market is rejected. The determined price is not an equilibrium point that accomplishes rational resource allocation, but the price like the natural level that the sequentially-adjustment of interest is performed, and this is changing dynamically. The amount of knowledge for expectation will increase through the transaction at a market. Indeed, this is the discovery process of the knowledge which Hayek talked about, and therefore, it is impossible to substitute a computer for a market.

In the point that the price is revised sequentially through a market, this probabilistic model may be also called a trial and error method. A trial and error method, however, is the pharisaical way that after gathering all information in one point, one function as tâtonnement or the Central Planning Board adjusts the price. On the other hand, in Caravale's adjustment process model, society is maintained by not the trial and error method, but inter-dependence relations between each agent who makes a network. In the meaning that an order is formed, Caravale's adjustment process model is similar to "a spontaneous order" of Hayek. In the thought of Hayek, however, a market is the place where the conflict of interest is adjusted and the knowledge is discovered, and to put it the other way around, if conflict of interest is adjusted and knowledge is perfect, rational resource allocation will be accomplished. In other words, Hayek shows the way to equilibrium. Many useful viewpoints are shown by the market process theory of Hayek, but in a certain sense, the theory may exist in general equilibrium theory. When a social cycle process (reproduction) is argued, Hayek's viewpoint is useful because a homogeneous agent, perfect knowledge and rational optimization behavior aren't assumed from the beginning. In the meaning of how an order as society is formed, spontaneous order (self-organization) theory will also coincide with reproduction theory. Caravale's model may be able to consider as the model which Hayek's viewpoint is absorbed into the reproduction theory.

5. Concluding Remarks

Conventional LPPs are regarded as the stability of *given* LPPs, because data changes are made harmless, only if they are *sufficiently slow*, compared to the speed of convergence of short-period magnitudes. Therefore, some persistence (chronological and theoretical) is required. However, stability has little or no place within the long-period framework, and if some persistence doesn't exist, new (different) data would lead to new different values for the endogenous variables, and these would not depict a long-period equilibrium. Especially, capital endowments in Walrasian, and produced quantities in Sraffian are the problems with which it should be deal. Such models don't hold to the inner logic which determines these: interaction between endogenous and exogenous variables. In real economies, however, it is considered that the outcome at a micro level and a macro level is in a looped relationship. The amount of aggregate demand as a result of consumers' decision-making is contained in the determination factor of the amount of aggregate supply. Furthermore, the amount of commodities demanded depends also on outputs as a result of producers' decision-making, prices and distributions. In other words, decision-making at a micro level plays important roles, and different adjustment paths may offer different rest points (LPPs): LPPs may become *path dependent*. Or rather, LPPs may not rest in a

conventional meaning.

The purpose of this paper is to offer the reproduction theory with eliminating the preconditions (given data, repetition of market conditions and uniform rate of profit) in classical theory. In this probabilistic model, Smithian tâtonnement exists, instead of a Walrasian tâtonnement that conventional models (especially so-called cross dual models) assume implicitly in short-period equilibria, and it is an essence of this model. Hence, there is a sequential adjustment process which considered decision-making of heterogeneous agents as intervention. This is an important point because it has described dynamics with holding reality. An adjustment is completed without severe conditions, and a system is maintained though fluctuations may occur. However, this model still assumes that the changes in quantities produced and the associated changes in the technical coefficients will not be drastic: some range of stationary state from the beginning. Stationarity, however, is a nature and the condition which should be satisfied, even if a system is nonstationary (see Nishibe 2000, p.4).

When a sraffian system is extended to dynamics, there are various difficulties. For one thing, Sraffa didn't consider the short-term adjustment process: elimination of a process analysis. When the adjustment process is considered and modeled, the view of market is important factor for those works, since the view of market governs a model. Therefore, it is important to reconsider the Economic Calculation Controversy.

There are problems in this probabilistic model. Firstly, when transactions are made at the market clearing price, there is a problem as to whether society can be reproduced by transactions at their prices or not. That is to say, is the result achieved in a short-term adjustment process enabled to be a viable condition? If not, how can viable condition be connected with the outcome? However, it's apparent that Caravale's model is an important one step about dynamics. Secondly, there is the problem that all commodity produced is taken to a market. It is necessary for enterprises to possess a buffer, for the preservation of the certain order without cumulative dis-equilibrium: an existence of inventories, because inventories will be a buffer to be accommodated to an accidental shock. This point may be also the issue which should be considered, but even in the primitive model, important insistence would be expressed sufficiently.

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