WP-2010-008

On the Notion of Equilibrium or the Centre of Gravitation in Economic Theory

Ajit Sinha

Indira Gandhi Institute of Development Research, Mumbai
July 2010
http://www.igidr.ac.in/pdf/publication/WP-2010-008.pdf

On the Notion of Equilibrium or the Centre of Gravitation in Economic Theory

Ajit Sinha
Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email (corresponding author): ajit.sinha@igidr.ac.in

Abstract

This paper is a critical examination of the notion of equilibrium in the classical theory of value. It highlights the theoretical importance as well as the problems associated with the notion of equilibrium in the classical theory and goes on to argue that Sraffa presents a theory of value within the classical tradition that does not require a notion of equilibrium of demand and supply, which succeeds in dissolving the problems associated with the classical theory of value. It also discusses the importance of the notion of equilibrium in the modern general equilibrium theory for the sake of continuity and completeness of the story.

Keywords:

Equilibrium, Centre of Gravitation, Price Theory, Theory of Value, Classical Economics, Neoclassical Economics, Sraffa

JEL Code:

B1, B2, B3, B4, B5

Acknowledgements:

I would like to thank Professor G.C. Harcourt for helpful comments and Professor P. Garegnani, the literary executor of Sraffa\'s unpublished papers, for his permission to quote from Sraffa\'s unpublished notes housed at the Wren Library, Trinity College, University of Cambridge.

On the Notion of Equilibrium or the Centre of Gravitation in Economic Theory

Ajit Sinha
Visiting Professor
IGIDR, Mumbai

This paper is a critical examination of the notion of equilibrium in the classical theory of value. It highlights the theoretical importance as well as the problems associated with the notion of equilibrium in the classical theory and goes on to argue that Sraffa presents a theory of value within the classical tradition that does not require a notion of equilibrium of demand and supply, which succeeds in dissolving the problems associated with the classical theory of value. It also discusses the importance of the notion of equilibrium in the modern general equilibrium theory for the sake of continuity and completeness of the story.

Introduction

The notion of equilibrium has played a critical role in economic theory since Adam Smith, and it is almost invariably invoked as an ideological support for the efficiency of the market in dealing with economic crisis. It is in the theories of value that the notion of equilibrium has played a crucial role and to the extent that a theory of value is fundamental to any economic theory of the capitalist market economy, it has remained critical to economic theorising in general.

In the classical tradition, the theory of value is concerned only with the commodities that are produced and the supplies of which can be increased or decreased by changing the labour and materials allocated to their production. In this context, the classicists maintain that the long-term values of commodities are determined by their 'costs of production', where 'cost of production' not only includes the material costs but also the uniform wages paid to the labourers and the uniform rate of profits received by the capitalists on their invested capitals (and in the case of Adam Smith, uniform rents received by the landlords on land as well). It is the condition of *uniformity* or *equality* of returns to factors in all the sectors of the economy that enables the classicists to derive or determine the long-term prices of the commodities. However, this

necessary condition for the determination of the long-term prices or what classicists call ‘natural’ prices is supposed to hold when the supplies of all the commodities are equal to their effectual demands. In other words, the determination of the natural-prices is based on the condition that equilibrium of demand and supply holds. In the neoclassical tradition, however, the theory of prices is built on the paradigm of pure exchange, and therefore it can determine prices without invoking the condition of the uniformity of the rate of profits. Nevertheless, it also requires some specification of the equilibrium condition for the determination of its prices. Though the Sraffians have remained strongly wedded to the notion of equilibrium, it is my contention that Sraffa (1960) breaks from both the traditions by showing that a theory of prices does not need the condition of equilibrium of demand and supply, thereby liberating the theory of prices from the shackles of equilibrium.

In this paper we are mainly concerned with the notion of ‘centre of gravitation’ in the classical tradition, which includes Sraffa. However, a brief discussion of the orthodox general equilibrium theories is also introduced for the sake of continuity and completeness of the story. Though Keynes’s *General Theory* has been interpreted in a Walrasian framework by many (see, for example, Hicks 1937, Pantinkin 1956), I have decided to leave it out on the ground that it is not a theory of prices. Marshall’s price theory has also been left out for being a partial equilibrium theory.[1]

The Classical Tradition

Even though Adam Smith never uses the word ‘equilibrium’ in a mechanical sense, he argues that empirical prices or the ‘market-prices’ at any given time are always gravitating toward a set of prices that in some sense is ‘natural’ and more stable. Adam Smith’s reasoning begins with the basic accounting principle that the value of the total net output produced in a

[1] However, see Harcourt (1981) for an interesting discussion on Marshall, Sraffa and Keynes in this respect.

production or a harvest cycle must be equal to the total net income generated in the economy. On the assumption that there are only three classes of recipients of income (landlords, capitalists and workers), he hypothesizes that at any given time the 'natural' wage rate and the 'natural' rate of profits are conventionally given data (actually they are supposed to depend on the historical rate of growth of the economy and certain social norms). Rent of land, in contrast, is determined in the food-producing agricultural sector, where both input and output can be taken to be the same good and hence the conventional 'natural' wages and profits can also be reckoned in the same good. It is Adam Smith's contention (which is in agreement with the Physiocrats) that there is always a physical residual of food left after deducting the 'seed' and the 'natural' wages and the 'natural' profits, which turns into an income category for the landlords as rent. From here on Adam Smith argues that the 'natural-prices' of all the commodities must *ultimately* resolve into 'natural' wages, 'natural' profits and 'natural' rents. In other words, given the 'natural' rates of wages, profits and rents plus the techniques of production in use, one can determine the set of 'natural-prices' as shown below:

$$(Ap + H)(1 + r) + tL = p,$$

where A is an nxn matrix of commodity inputs $a_{ij,}$ which represents the quantity of good j required to produce, on average, 1 unit of good i. We take good one as 'corn' with a_{11} positive and all other a_{ij} elements as zero in the first row of matrix A. H, L, and p represent vectors of labour time, land units and the 'real price' or the labour-time commanded respectively (thus the wage rate by definition is equal to one). And r and t represent the rate of profits and rent per unit of land respectively. On the assumption that Hawkins-Simon condition holds, we can represent our production system in terms of Adam Smith's price equations as:

$$(H + rH + tL) = p – Ap(1 + r) = [I – A(1 + r)]p$$

$p = [I – A(1 + r)]^{-1} (H + rH + tL)$; given that equations are independent. This can be

expanded as:

$$p = [I + A(1+r) + A^2(1+r)^2 + A^3(1+r)^3 + \ldots] (H + Hr + tL)$$

This resolves all prices into wages, profits and rent. Of course, Adam Smith did not argue his case in such a mathematical manner but his theoretical argument can be fairly represented by these mathematical equations (for details on Smith's theory of value, see Sinha 2010a,b).

These natural-prices are determined on the condition that the uniform rates of wages, profits and rents prevail. It is Adam Smith's contention that if the quantities demanded and the quantities supplied of various commodities are not equal then the market-prices of commodities with excess demand would rise above their natural-prices and the converse would occur for the commodities with excess supply. He further argues that if the market-price of a commodity is higher than its natural-price, then one or more factors associated with its production must receive higher income than their 'natural' rates and the converse for the commodity with a lower market-price than its natural-price. This, according to Adam Smith, would**,** under the condition of free competition**,** trigger a movement of factors from the sectors where their incomes are lower than their 'natural' rates to the sectors where those factors are receiving higher than their 'natural' rates, bringing in its wake an increase in the supply of the commodities that were in excess demand and conversely for the commodities that were in excess supply. And as supplies adjust to demands, the market-prices move toward their natural-prices.

But what ensures that quantities supplied would be equal to quantities demanded when all the market-prices are equal to their respective natural-prices? Adam Smith's answer to this problem is that demand must be 'effectual', i.e., it must be backed by real ability to buy. But the real ability to buy comes from real income, which is generated in production. How much income is generated can only be determined if not only the techniques in use but also the size of the economy or the total employment of labour is known. In other words, Adam Smith begins with a

given empirical economy with its inputs and outputs as known data (similar to Sraffa). The argument runs as follows: the given empirical set of outputs generate a set of incomes that generate a set of quantities demanded. This set of quantities demanded may not match one to one with the outputs produced. The idea of 'effectual demand' refers to the fact that the economy should be able to produce the set of 'effectual demands' by *reallocating its given employment of labour*. In other words, on an implicit assumption of constant returns or linear techniques, any given economy can produce many sets of output combinations by reallocating its given total labour employment. Any such sets of outputs could represent the set of effectual demands. The gravitation mechanism is designed to argue that market-price signals direct reallocation of labour such that the economy would eventually produce exactly what is demanded. Thus supplies would match the quantities demanded one to one and market-prices would coincide with natural-prices, as the only cause of divergence of market-prices from natural-prices is the incongruence between supplies and effectual demands:

> The natural price, therefore, is, as it were, the central price, to which the prices of all commodities are continually gravitating. Different accidents may sometimes keep them suspended a good deal above it, and sometimes force them down even somewhat below it. But whatever may be the obstacles which hinder them from settling in this centre of repose and continuance, they are constantly tending towards it (Adam Smith [1776]1981, p. 75).

So what role does the notion of gravitation play in Adam Smith's theory of prices? It is clear that Smith's natural-prices are determined by the *objective* input-output data of any given economy and the distribution of income given by the history of economic growth and social norms and the productivity of the food-producing land, which allows no role for individual human psychology or motives. But Smith also believes that the economic actors are individual human beings who act on certain motives, particularly to improve their conditions whenever there is an opportunity to do so. The notion of gravitation allows him to put all these

psychological aspects in one box and show that their influence is to generate a sort of gravitational force on both supplies and market-prices toward effectual demands and natural-prices respectively. Clearly the notion of equilibrium is critical to Adam Smith's theory of value, as the conceptual legitimacy of the notion of natural-price rests on its being the equilibrium market-price. Nevertheless, the role of the market-mechanism and the *subjective* motives of the agents that lie behind the market forces are minimised to the extent that their influence on prices has been revealed to be ephemeral and that the long-term stable prices are shown to be independent of the subjectivities of the agents.

The neoclassical reading of the Classical Economics, led by Samuel Hollander (1973, 1979, 1992), argues that it is incorrect to suggest that the natural-prices of classical economics are independent of demand factors. Hollander argues that Adam Smith and other classicists assume *constant costs* in the context of the gravitation mechanism only for illustrative simplicity. His contention is that classical economists begin their analysis with given endowments; thus a change in demand patterns, say a shift in consumption demand from a 'capital intensive' to 'labour intensive' good, would increase the total demand for labour and therefore wages, causing techniques of production to shift in favour of relatively 'capital intensive' techniques, which in turn must cause changes in the natural-prices of goods. The weakness of this interpretation lies in the fact that it is unable to account for Adam Smith's notion of 'effectual demands' as demand points backed by real income. In our interpretation presented above, the 'effectual demands' are well defined points and given that the gravitation mechanism is concerned with reallocation of the total employed labour of the empirical economy, the question of a rise or fall in the demand for labour in the context of the gravitation mechanism does not arise. Therefore, in this context an implicit assumption of constant returns implies constant costs as well.

Ricardo ([1821] 1951) accepts Adam Smith's description of the notion of the centre of

gravitation: “In the 7th chap. of the Wealth of Nations, all that concerns this question is most ably treated”. He, however, develops his theory of value in opposition to Adam Smith’s. According to Ricardo, Adam Smith first takes the natural rates of all the three income categories as independently determined or given from outside, and then he simply adds up the three income categories to determine the natural-prices. Since then this has been the dominant interpretation of Adam Smith’s theory of value (for a critique of this interpretation, see Sinha 2010a,b). On the basis of such an interpretation, it has been alleged that Adam Smith maintained that a rise in wages would lead to rise in the prices of all the commodities leaving the rate of profits and rent unaltered. If this interpretation is correct, then it is quite clear that Adam Smith’s theory of value fails to take into account the constraint binding on the total income and thus makes a logical error. Against Smith’s ‘adding-up theory’ of value, Ricardo wants to establish that a rise in wages *must* lead to a fall in the rate of profits. To establish this, he proposes a labour theory of value, which suggests that natural-price ratios of commodities are proportional to their sum of direct and indirect labour required to produce the commodities.

Ricardo argues that Adam Smith is wrong in claiming that the labour (embodied) theory of value is valid only in the context of labour being the sole factor of production as well as the sole recipient of income and that as soon as profit (and also rent) appears as an independent category of income, the labour theory of value becomes invalid by virtue of it. Ricardo goes on to show that the labour theory of value remains a valid theory of natural-prices even when the rate of profits is positive as long as the ratios of direct to indirect labour remain uniform for all the sectors, implying that emergence of profit as an income category does not by itself invalidate the labour theory of value, as claimed by Adam Smith. He, however, acknowledges that when the ratios of direct to indirect labours are not uniform then the natural-prices of commodities must deviate from their labour-value ratios. But this does not deter him from arguing that even though

the natural-prices diverge from their respective labour-value ratios, the sole cause of changes in the natural-prices is still the changes in the labour-values of commodities (see Sinha 2010a for details). Given that his main concern was to show that a rise in the value of wages must lead to a fall in the rate of profits, it was sufficient for him to maintain that the changes in the value of wages itself will not have any impact on the natural-prices, whatever the natural prices happen to be. But, yet again, Ricardo has to acknowledge that the same cause that deviates the natural-prices from labour-value ratios also operates as one of the causes of change in the natural-prices and thus it cannot be denied that a rise or fall in the value of wages would affect the natural-prices. Ricardo apparently held the incorrect belief that the effect of changes in the value of wages on the natural-prices is only apparent and is solely due to a lack of an 'invariable measure of value' in nature—this problem kept him preoccupied till the end of his life (see Sinha 2010a,c). In any case, in the *Principles* he takes refuge in the expedient that in the real world the effect of changes in the value of wages on the natural-prices are minor and can simply be ignored. On this supposition he could then show that a rise in the value of wages must lead to a fall in the rate of profits as long as land and rent could be kept out of the picture.

To 'get rid' of rent from the consideration of a theory of natural-prices and the proposition regarding the inverse relation between wages and the rate of profits, Ricardo proposes a theory of rent according to which the productivity of marginal land declines with extension of agriculture or employment of further doses of capital and labour on the same land beyond the optimum combination of the three factors. Ricardo argues that rent as an income category arises solely due to the natural differential productivity of land. The extent of the cultivation of land and the extent of the employment of capital and labour on any given plot of land are determined by the size of the population at any given point of time. Given the margin of land under cultivation, the extra produce on all the intra marginal land turns into rent, whereas marginal land (or the marginal

dose of capital and labour) itself does not pay any rent. Ricardo argues that it is only the marginal land that is relevant in determining the natural-prices in his theory and therefore, rent plays no role in the determination of natural-prices.

Though the theory of differential rent is crucial to Ricardo's theory of value and distribution, it nevertheless causes a serious problem for his proposition regarding a centre of gravitation. Ricardo argues that the extension of cultivation is determined by the size of the population and hence the gravitation mechanism itself cannot affect the margin of cultivation and the natural-prices. He, however, does not consider the case of manufacturing sectors requiring agricultural raw materials. If the manufacturing sectors require agricultural produce as their raw materials such as cotton, jute, tobacco, etc., then it cannot be denied that a reallocation of labour between manufacturing sectors may affect the demand for the agricultural raw materials and hence the overall margin of cultivation. And once the margin of cultivation is affected, it must affect the natural-prices as well as the rent, wages and the rate of profits in the system. Therefore, it can no longer be argued that natural-prices are independent of demand patterns or that distribution of income can be separated from natural-price determination. As Samuelson argues, "The point is obvious that any classicist who thinks he can separate 'value' from 'distribution' commits a logical blunder. He also blunders if he thinks that he can 'get rid of land and rent as a complication for pricing' by concentrating on the external margin of no-rent land: where that external margin falls is an *endogenous* variable that shifts with tastes and demand changes so as to vitiate a hoped-for labor theory of value or a wage-*cum*-profit-rate theory of value" (Samuelson 1978, p. 1420).

The Neoclassical Tradition

Though no classicist ever proved the hypothesis that the price signals in the market necessarily lead the market-prices to the long-term equilibrium prices given by their natural-

prices, this hypothesis was never seriously challenged and was accepted by most as self evidently true. J.S. Mill (1848) went to the extent of suggesting that 'dealers' often change prices in response to changes in the cost of production in anticipation of the supply response, without supply actually having to respond. Marx ([1867] 1977) went on to call the gravitation mechanism, the *law* of value. The modern marginalist or neoclassical theory of value that came into being with Jevons ([1871] 1957) and Walras ([1874] 1954) also does not question the classical notion of equilibrium and gravitation. Their attempt is to dethrone the classical theory of natural-prices, which determines the equilibrium prices by objective data alone. They argue that equilibrium prices are determined only by the forces of supply and demand, where demands of the final-goods reflect the subjectivities of the consumers. They further argue that commodities have prices not because it 'costs' to produce them but rather because they are 'scarce' and the scarcity of a commodity is a function of the subjectivity of the consumer. Even when they introduce production explicitly in their theories, they interpret 'costs' of production from the subjective perspective as 'disutility' (see Bharadwaj 1978 for more details).

Walras distinguishes all useful goods into two categories: (i) 'unlimited' in supply such as air and water and (ii) 'limited' in supply. According to Walras, the 'unlimited' goods are free but all the goods with 'limited' supply are 'scarce' and, due to their scarcity, have positive prices. Later Wald ([1936]1951) showed that the solution of Walras's equations cannot rule out some commodities being permanently in excess supply and thus those commodities must be assigned zero prices. The upshot of Wald's result is that commodities cannot be classified as 'scarce' prior to the determination of the equilibrium prices and therefore scarcity cannot be taken as the *cause* of positive prices. To say that all goods that have positive prices are 'scarce' is nothing but a tautology, and, as with all tautologies, it provides us with no useful information. In any case, Walras's great achievement, at least in his own opinion, is to, for the first time, mathematically

'prove' that in a perfectly competitive market at least a set of prices exists for which the respective supplies and demands of all the commodities are equal. But Walras's contention of the greatness of his achievement is not only the proof of the existence of equilibrium but rather that the equilibrium is *stable*. In other words, he argues that in a perfectly competitive market there exists an inherent mechanism that brings disequilibrium prices to their equilibrium. Walras's mathematical proofs of either the existence of equilibrium or its stability are, however, not rigorous—he simply takes the condition of equality of the numbers of independent equations and the unknowns in the system of equations as proof of the existence of a solution; and in the case of the stability of equilibrium, he simply argues that a competitive market mimics his theoretical devise of an auctioneer. It should, however, be noted here that the notion of perfect competition in Walras and the neoclassical tradition in general is not the same as the notion of free competition of the classical tradition. In the neoclassical tradition, the notion of perfect competition implies that the agents are 'price takers' or, in other words, their theoretical models take prices as parametrically given; whereas in the classical tradition, the agents actively raise or lower the prices in response to the market conditions (see Hollander 1973 and Eatwell 1987).

After the powerful paper by Wald, it became clear that the problem of the existence of equilibrium itself was highly complicated and the profession separated the problem of 'existence' from the problem of 'stability'. Only in the 1950s was it shown by Arrow and Debreu (1954) and McKenzie (1954) that under highly restrictive assumptions the existence of one or multiple 'equilibrium' prices for a Walras-type system of equations can be proved. However, their condition of equilibrium does not require the classical condition of equality of the rate of profits even when production is incorporated within their general exchange model. The works on the 'stability' of equilibrium, however, has concluded that the stability of 'equilibrium' cannot be guaranteed (Gale 1963, Sonnenchein 1972). One simple reason for this is that in the case of

positive excess demand for a good, when its price is raised it simultaneously raises the income of those who supply that commodity and there is no way of denying *a priori* that the positive income effect will not be greater than the substitution effect of a price rise, resulting in contraction of its total supply rather than the required increase in it for the stability of the equilibrium in its neighbourhood. Moreover, it has also been found that the process of arriving at equilibrium is contingent upon the choice of the *numéraire*, which makes the stability property of the equilibrium quite arbitrary (see Arrow and Hahn, 1971). But once it is accepted that 'equilibrium' may not be stable then such a notion of 'equilibrium' looses most of its force. Now it cannot be argued that there exists an inherent force in a perfectly competitive market that ensures that disequilibrium situations are short lived and that the market has the ability to self-correct itself. Thus, in this context, the notion of 'equilibrium' reduces to a mere formal condition that allows for a solution of a simultaneous equation problem. Without the notion of equilibrium we do not have any means of determining the prices of all the commodities in the General Equilibrium framework.

The Sraffians

Though the problem of the existence and stability of equilibrium within the Walrasian tradition was thoroughly investigated during the second half of the Twentieth Century, its classical counterpart remained ignored. A champion of the classical tradition, Pierangelo Garegnani (1976) goes to the extent of arguing that the notions of equilibrium of the classical and the early neoclassical traditions are the same (or at least similar) and that there is no problem with it. According to Garegnani, the fundamental problem with the theory of value in the Walrasian tradition is that, on the one hand, its competitive equilibrium condition requires that the rates of profit in all the sectors must be equal, which in turn requires that all physical capital-goods must be aggregated into a homogeneous unit; whereas, on the other hand, there are no means by which

heterogeneous capital-goods could be aggregated prior to the determination of prices. It was the problem of aggregation of heterogeneous capital-goods, in Garegnani's opinion, that led the Walrasian tradition to break from the notion of equilibrium defined by the equalisation of the rate of profits across sectors:

> The study of the permanent effects of changes by means of comparisons between positions of the economic system characterized by a uniform rate of profits was in fact the method used by Ricardo and the English classical economists, when they explained profits in terms of the surplus product left after paying wages at the rate determined by independent economic or social circumstances. But fundamentally the same method was preserved after Ricardo, across the deep change which the theory underwent in favour of a symmetric explanation of profits and wages in terms of the equilibrium between the forces of demand and supply for labour and capital. … It was only in the last few decades that this method, which was centred on 'long-period positions' of the system … was increasingly challenged: … this departure from tradition has not been due to weaknesses of the method as such, but rather to weaknesses of the dominant theory of distribution and, in particular, of the conception of capital it relies on. (Garegnani 1976, 25-26).

It was only in 1984 that Steedman (1984) raised some doubts about the viability of classical gravitation mechanism. Steedman's paper was, however, criticised from the Sraffaian and Marxist quarters. Unfortunately, many of the papers (e.g., Boggio 1992; Dumenil and Levy 1985, 1987; Flaschel and Semmler 1987; Franke 2000) that try to show that the classical centre of gravitation is a robust idea make a simple mistake of conflating the context of growth with the context of the gravitation mechanism (Steedman 1984 has also not conceptually distinguished the two contexts). What they effectively argue is that, given an infinite labour supply at a fixed real wage, the economy will eventually converge to a balanced growth path. But, as we have argued above, the classical economists separate the problem of allocation of labour from the problem of economic growth. The gravitation mechanism is exclusively designed to deal with the problem of allocation of labour and not with the problem of growth. The allocation context is well defined by a given set of affordable demands referred to as given 'effectual demands'. In the growth context, however, the set of 'effectual demands' cannot be taken as given.

The classical economists, moreover, are quite clear that the techniques of production in use as well as the 'natural wages' or the 'natural rate of profits' etc. cannot be held constant in a growth context. For example, in the case of Ricardo, an increase in the size of the labour force must bring diminishing returns into play in the agricultural sector; and in the case of Adam Smith, the expansion of the size of the market should lead to increasing returns of one kind or the other. In Sraffa's system, the theoretical distinction between the problematic of allocation of labour and growth becomes much sharper. To any given system of production there exists a unique *Standard system*, which is a particular *reallocation of its given total labour*. This Standard system is associated with a set of all possible reallocation of the given total labour with the same techniques—that is, any such possible allocation can be taken as an equivalent of the given system. It is this set that defines the universe of the problem of allocation of labour pure and simple. But, whenever total labour is allowed to change (given the same techniques), which must be the case in the context of growth, the Standard system must change, as the Standard system not only depends on the techniques of production but also the size of the total labour of the system. Thus even when we assume constant returns and balanced growth, we cannot maintain that the system remains the same. It must continuously be changing as its utilisation of total labour changes. Furthermore, some of these papers (e.g., Dumenil and Levy, 1987; Nikaido, 1983) only deal with two-good models. If, however, the system exhibits chaotic dynamics, then such models would simply fail to capture them, as chaotic dynamics require at least three degrees of freedom, which is possible only in a system with at least three goods.

Garegnani (1997), however, argues that the classical theory of the centre of gravitation is robust in the context of the given size of the economy. In his criticism of Steedman (1984), Garegnani first correctly points out that "the level of aggregate demand is assumed constant in terms of level of aggregate labour employed", but then he uses this for the wrong purpose. There

is no specification of a vector of the fixed aggregate or effectual demands in his model and he, like others who situate the problem in the growth context, simply assumes that when the rate of profits is uniform then the supplies *must* be equal to the effectual demands. He starts with an economy in disequilibrium and calculates the ratios of market prices to what would be their natural prices (m_i/p_i). He argues that the lowest of the m_i/p_i must have a rate of profit $r_i < r^*$ and the highest of m_j/p_j must have $r_j > r^*$, where r^* is the uniform rate of profits in the system. He takes a commodity with the lowest rate of profit, say r_h, and argues that the behavioural assumption of the gravitation mechanism requires that the output of sector h, say O_h, must decline. From here on he makes a specific *assumption* that a fall in O_h must immediately lead to a rise in r_h. He, however, is well aware of the fact that this assumption is unjustified, as the fall in O_h due to the behavioural assumption may be associated with a larger fall in the demand for h due to supply adjustments in other sectors. In that case r_h should fall further rather than rise. At this stage Garegnani invokes the condition of given size of the economy by the total labour in use. He argues that if h is a basic good then the demand for it cannot fall below a minimum, otherwise the system will breakdown. On this basis he concludes that *eventually* a fall in O_h must lead to a rise in r_h (p. 147). It should be noted here that Garegnani by decree stops the system from breaking down. There is, however, nothing in the behavioural assumption of the gravitation mechanism that stops the system from breaking down and Gragnani gives no reason why the adjustment mechanism of the n basic-good sectors must stop before one basic-good sector contracts so much that the system breaks down. His decree leaves only two options for the system: either to converge or to oscillate around some point.

Garegnani's defence of the centre of gravitation works on the argument that if it is accepted that the rate of profit of the minimum profit sector must rise, then when it equals the rate of profit of some other sector, say sector k, then r_k must also begin to rise along with the first one

r_h. This crucial hypothesis, in my opinion, is false. Recall that Garegnani had invoked the idea of minimum effectual demand for the minimum rate of profit sector to argue that *eventually* a fall in its output must lead to a rise in its price, but when some other commodity's rate of profit becomes equal to the rising rate of profit of the minimum sector, there is no reason to believe that its output at that stage would be at the *minimum* level for the system to survive. Thus there is no reason to think that supply adjustments in other sectors will not be such that they reduce the effective demand for commodity k more than the fall in its output O_k and thereby dragging r_k below the current level of r_h. Thus several rates of profits could keep oscillating below r* and never get there.

Only recently Dupertuis and Sinha (2009) have shown that, in a carefully demarcated context of reallocation of labour, as opposed to the context of growth, the classical gravitation mechanism does not work. They work out eight possible different dynamic scenarios of adjustment of supplies to given effectual demands through price signals and quantity adjustments, including the specific classical scenario, while keeping the size of the economy or its total employment constant throughout the process. They find that in all such scenarios the probability of the system of three or more basic-goods converging to its centre of gravitation is zero.[2]

Leaving aside the complexity of the dynamics of quantity adjustments on the basis of price signals for three or more goods with fixed aggregate labour, it can be shown that when the condition of the uniform rate of profits in the system and the role of prices are properly understood it becomes clear that the classical understanding of the gravitation mechanism is conceptually unsound. Based on my understanding of Sraffa (1960), below I first establish why

[2] It should be pointed out though that all these results do not suggest that the system can never converge. All it says is that possibility of that happening is most unlikely—in mathematical terms the probability of convergence is zero.

the rate of profits *must* be uniform for all the sectors in a given system of physical inputs and outputs and the distribution of its net income given from outside the system. On the basis of this, I demonstrate the reason why the classical notion of the centre of gravitation is not a sound concept.

Sraffa

Let us take Sraffa's example (1960, p. 19) of a system of production that produces a surplus:

90t. iron + 120t. coal + 60qr. wheat + 3/16 labour → 180t. iron
50t. iron + 125t. coal + 150qr. wheat + 5/16 labour → 450t. coal **I**
40t. iron + 40t. coal + 200qr. wheat + 8/16 labour → 480qr. wheat

180t. iron + 285t. coal + 410qr. wheat + 1 labour → 180t. iron + 450t. coal + 480t. wheat

And in terms of its price equations the system is represented by:

$(90Pi + 120Pc + 60Pw)(1+Ri) + 3/16\ \omega = 180Pi$
$(50Pi + 125Pc + 150Pw)(1+Rc) + 5/16\ \omega = 450Pc$ **I'**
$(40Pi + 40Pc + 200Pw)(1+Rw) + 8/16\ \omega = 480Pw$

$(180Pi + 285Pc + 410Pw)(1+R) + \omega = 180Pi + 450Pc + 480Pw$

In this system, prices cannot be determined unless the rule for distribution of the surplus is known. Sraffa asserts that the sectoral rates of profit *must* be uniform. If that is so then given wages, the two relative prices and the uniform rate of profits of the system could be simultaneously determined. It has been almost universally interpreted that Sraffa's claim that the rate of profits must be uniform is an admittance of the competitive equilibrium condition or the condition of the centre of gravitation (see John Hicks 1985 for an exception).[3] Without going into

[3] "Sraffa leaves us to find out what his prices are, but I doubt if they are equilibrium prices. They seem to be prices which are set upon products, by their producers, according to some rule. Now it is perfectly true that we are nowadays familiar with that method of price-fixing, by 'mark-up'; but when that method is used, the rate of profit that is used to establish the mark-up is conventional. Now it may be that Sraffa wants us to think of his rate of profit as being conventional; and that the uniformity of the rate of profit throughout his system, of which he makes so

exegetical arguments that Sraffa did not think in terms of equilibrium of demand and supply (see Sinha and Dupertuis 2009a and Sinha 2010a for details on this point), let me here motivate a logical argument behind the condition of the uniformity of the rate of profits independently of the notion of equilibrium of demand and supply. After which I present some evidence from Sraffa's published and unpublished writings that show he argued in a similar manner.

Let us assume an imaginary system given by:

120t. iron + 160t. coal + 80qr. wheat + 1/4 labour → 240t. iron
40t. iron + 100t. coal + 120qr. wheat + 1/4 labour → 360t. coal **II**
40t. iron + 40t. coal + 200qr. wheat + 2/4 labour → 480qr. wheat

200t. iron + 300t.coal + 400qr. wheat + 1 labour → 240t. iron + 360t. coal + 480t. wheat

And in terms of its price equations, the system is represented by:

$(120Pi + 160Pc + 80Pw)(1+Ri) + 1/4\ \omega = 240Pi$
$(40Pi + 100Pc + 120Pw)(1+Rc) + 1/4\ \omega = 360Pc$ **II'**
$(40Pi + 40Pc + 200Pw)(1+Rw) + 2/4\ \omega = 480Pw$

$(200Pi + 300Pc + 400Pw)(1+R^*) + \omega = 240Pi + 360Pc + 480Pw$

System-II is nothing but Sraffa's Standard system for the given empirical system-I. It redistributes the total labour of the system or rescales the real system in such a way that the aggregates of its inputs and outputs come out in the same proportions. Let us assume that wages are zero, then in the above given example of system-I, if the aggregate or the global rate of profit of the system is given by R, then the value of (1 + R) = (180t. iron + 450t. coal + 480t. wheat)/(180t. iron + 265t. coal + 410t. wheat). Now, if we multiply the physical amounts of iron, coal and wheat by taking several arbitrary prices of iron, coal and wheat, we would find that the value of the above given ratio will change with changes in prices. However, since the physical ratio remains the same, it immediately tells us that prices can create a 'nominal' effect on R (a

much, is just a uniformity of convention" (Hicks 1985, p. 306).

sort of optical illusion), which is completely independent of its physical property. Nevertheless, at this level one can at least establish that the physical ratio of (R) gives us the rate of expansion of this economy, as by multiplying the aggregate of inputs with the physical ratio of (1 + R) we get exactly the aggregate of gross output of the system. Now, in the imagined system-II, the *global* rate of profit or the ratio of the aggregate physical net output to the physical aggregate inputs can be known without the knowledge of prices since it is a ratio of heterogeneous goods made up in the same proportion. This ratio is completely independent of prices—no matter what prices prevail, it will not affect the global rate of profit of the *Standard system*. Let us say that this ratio is equal to a number R*, by our example it is equal to 1/5 or 20%. Thus, we come to our first conclusion that, as far as the *Standard system* is concerned, its global rate of profit is the physical property of the system of production and its value is known independently of prices. But since the real system is nothing but an *equivalent* system to the *Standard system*, the physical rate of profits in the two systems must be equal, i.e. R* = R; as the real system is nothing but the rescaled Standard system. This property must hold for all the systems derived from rescaling the Standard system and this is possible if and only if all the sectoral rates of profit of the systems are uniform or equal. This is a physical property of the system and prices must be such that this property holds. From here it is a small step to show that this property must hold when wages are positive as long as the wages are measured in the *Standard commodity*, which is a 'composite commodity' made up of all the basic goods put together in the *Standard* proportion. Once the proposition that distribution of income is given from outside the system of price determination is accepted, the corollary of this proposition is that the system cannot admit any other set of prices that results in R being not equal to R*, simply because R* is the only rate of profit that is independent of prices while all other R's are dependent on prices. The point can also be illustrated in another manner.

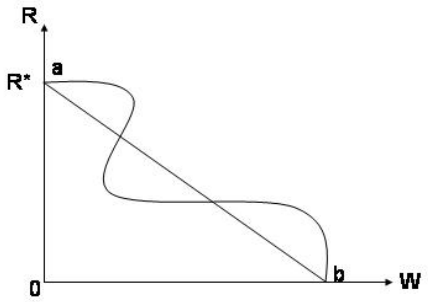
Let us take the real system-I and assume that the rate of profits is equal in all the sectors. In this case, given wages we can solve for a set of prices and the rate of profits of the system measured by any arbitrary *numéraire*. Now, if we change the wages (say from zero to its maximum value) all the prices must change to ensure the equality of the rate of profits, since the ratio of means of production to labour in all the sectors are unequal. It is well known that the relationship between the wages and the rate of profits so derived would be a non-linear inverse relation. The non-linearity of this relation implies that the size of the total net output measured by the *numéraire* changes as the distribution of the given net output changes. This happens because the size of the *numéraire* or the measuring rod itself is affected by the changes in distribution. Sraffa argues that if the Standard commodity is used as the *numéraire* it can be shown that the relationship between wages and the rate of profits would be linear, which is given by $r = R(1 - w)$, where r is the uniform rate of profits in the system, R is the maximum rate of profits of the system and w is the wage rate measured in the Standard commodity. In other words, the Standard commodity is not affected by the changes in distribution of the given net income.[4]

Now, for our argument, let us begin with zero wages and equal rate of profits and a set of prices measured in the Standard commodity. Then we give some positive wages in terms of the Standard commodity, if we keep the old prices then it must generate unequal rates of profits in all the sectors as the ratios of means of production to labour in all the sectors are unequal. These unequal rates of profits would most likely generate a global rate of profit (i.e., the weighted average rate of profit for the aggregate of all the sectors) for system-I that will fall off the earlier straight line relation between wages and the rate of profits drawn on the condition that the rate of profits are equal throughout. As a matter of fact, if we keep the old prices constant and go on increasing the wage from zero to its maximum value, we would trace out a non-linear

[4] Baldone (2006) has confirmed that Sraffa's Standard commodity makes the *numéraire* effect null.

relationship between wages and the global rates of profit, which may cut the earlier straight line relation a few times (see figure 1). This is a general case for all sets of prices that generate unequal sectoral rates of profits in the system. However, the non-linear relation between wages and the global rates of profits generated by those prices implies that accounting of the total net income by such prices is inconsistent, since the size of the pie cannot change simply by cutting it in different proportions. Hence it is a logical property for any given system of production that its prices should be such that the sectoral rates of profits of the system are equal. This proves that the solution of a set of prices does not need any notion of equilibrium. Prices of any given system of production and distribution can be determined by the given objective data of its inputs and outputs along with the knowledge of the wage rate or the rate of profits of the system. Prices have a job to do and their job is to consistently account for the distribution of the net income between the two classes. Once it is taken that labour is homogenised by the given wages and given from outside the system, a logical corollary of it is that the remaining income must be distributed to the capitalists in equal proportion to their size of capital.

Wage-Profit Relation



Below I produce some evidence from Sraffa's writings that seems to support our argument above. In the *Production of Commodities*, Sraffa seems to be arguing in a similar manner when he declares that the mathematical property of the rate of profit of the Standard system commutes to the real system:

> But the actual system consists of the same basic equations as the Standard system, only in different proportions; so that, once the wage is given, the rate of profits is determined for both systems regardless of the proportions of the equations in either of them. Particular proportions, such as the Standard ones, may give transparency to a system and render visible what was hidden, but they cannot alter its mathematical properties (Sraffa 1960, p. 23).

The reader should note that the classical condition of supplies equal to the effectual demands cannot be a 'mathematical property' of the system. It should also be noted that Sraffa could not implicitly assume that supplies were equal to their effectual demands for both the real and the *Standard* systems—it would be bizarre to assume that the effectual demands were in Standard proportion even in an imaginary world. Thus Sraffa could not impose the condition of a uniform rate of profits on his *Standard system* on the basis of the so-called implicit assumption that the system is at its centre of gravitation. Hence the rate of profit of the *Standard system* that Sraffa is referring to above is the *global rate of profit* of the *Standard system* and the claim is that the two *global rates* must always be equal as long as the wages are measured by the Standard commodity. It is the proposition regarding the equality of the *global* rates of profit of the rescaled systems that allows Sraffa to directly deduce that all the sectoral or industrial rates of profits *must* also be uniform in the two systems, as we have argued above. This point becomes clearer in the very next paragraph from the above quoted passage:

> The straight-line relation between the wage and the rate of profits will therefore hold in all cases, provided only that the wage is expressed in terms of the Standard product. The same rate of profits, which in the Standard system is obtained as a ratio between

> *quantities* of commodities, will in the actual system result from the ratio of aggregate *values*. (Sraffa 1960, p. 23).

The reader should note that both the ratios of "quantities of commodities" and of "aggregate values" are well defined only at the *global* level and has no meaning at the local or industrial level.

Further on, in his unpublished notes written in 1955, we find that Sraffa invokes similar reasoning behind the possibility of an existence of a *Standard commodity*:

> With changes in w --
> The impulse towards price change is an internal one to each industry. It arises from its own internal conditions—not from those conditions <u>compared</u> with those of other industries. Hence the possibility of an <u>invariable</u> commodity. (PSP D3/12/59, emphasis in original).

Recall the discussion on the Standard commodity in Sraffa (1960). We start with zero profits and all income going to wages. Then wages are reduced by a certain percentage. Sraffa's argument is that this gives rise to a positive global rate of profit and all the sectoral rates of profit equal to it. Given that all the rates of profit must be equal, the old prices applied to the goods create surpluses and deficits in the sectors given their different proportions of labour and means of production. And it is these surpluses and deficits that force the sectors to adjust their prices. That is why a sector which will not have any surplus or deficit will have no compulsion to change its price and hence the possibility of an 'invariable commodity'. If one allows the gravitation mechanism to explain the equality of the rate of profits in the system then no commodity could stay invariant. The difference between the two approaches is this: In Sraffa's case, the condition of equal rate of profits is given or must be applied on the system in all the circumstances and prices change as a *consequence* of this condition. Hence the idea of change based on *comparison*

with other industries is categorically denied. In the classical case, on the other hand, the rates of profit eventually become equal as a *consequence* of changes in prices, which are explained precisely in terms of *comparison* with other industries.

As Sraffa in another note of 1955 writes:

> …, the rate of profits at the various individual levels of $\underline{w}$ will be $r = R(1-w)$. Individual prices will move in all directions with the variation of $\underline{w}$, but here again prices will make no difference: $\underline{r}$ is a ratio between two quantities of the same composite commodity and can actually be discovered before knowing what those prices are. The rate of profit is embedded 'in the things' and no manipulation of prices could ever affect it. [There could be no more tangible evidence of the rate of profits [being, as] a non-price phenomenon (effect)]. (PSP D3/12/53, all parentheses and brackets are in original).

Yet again it is claimed that the real rate of profits must be identical to the Standard global rate of profit. This finding shows that uniformity of the rate of profits in the system has nothing to do with the equalization of the supplies with their effectual demands.[5] As a matter of fact, relative prices cannot go anywhere they like—they are completely constrained by the system of production and distribution. In some sense Sraffa's result points to a similar break in economics as the break from classical mechanics to quantum mechanics.[6] The classical and neoclassical economics treat individual industries as independent entities, which through their interaction generate centres of gravitation that bring a system into being. Sraffa's result shows that the

[5] Joan Robinson (1961) had come closest to understanding this as she claimed that the "clue" to understanding the *PCMC* could be found in the 'corn model' of Sraffa's (1951) 'Introduction' to Ricardo's *Principles*. In the 'corn model', e.g. 1 ton of corn produces 1.5 tons of corn; the rate of profit is 50% no matter what is the final demand for corn. This physical relationship between inputs and outputs that is palpably evident in a single basic good model is obscured in n-basic goods model. But Sraffa's analysis with the help of the Standard system reveals that the insight of the corn model remains valid in a more general case as well.

[6] It may be noted that Sraffa was well aware of the developments in quantum mechanics. As early as 1928, he had noted down a passage from H.S. Allen's paper on 'The Quantum Theory' published in *Nature*, where Allen writes, "Heisenberg put forward the demand that only such quantities as are observable should be represented in the mathematical formulation of atomic theory. … This led to the development of the matrix mechanics, every term in a matrix corresponding to something which is, at least ideally, observable." Of course, Sraffa makes the same demand for economic theory. Furthermore, Heinz Kurz has informed me that "There are several books devoted to (what was then) modern physics in Sraffa's library. And in some of that there are annotations. Not many, but apparently Sraffa had read or at least skimmed through the books. In his papers he also refers to books that are not in his library, e.g. Bridgman."

system is not made up of independent industries but must be treated as an interconnected whole unit and the properties of the whole determine the properties of its parts.

Once the role of prices and the logical condition of the uniformity of the rate of profits in the system is understood, it becomes easy to understand why the classical notion of the centre of gravitation is not a sound concept. Since the movement of given supplies to their effectual demands must maintain the techniques in use and the total labour in the system constant throughout, it implies that all those sets of supplies must have the same Standard system. Thus for every supply set the solution of its prices must be the same if the wages and the *numéraire* are kept constant. However, the gravitation mechanism requires that that such supply sets throughout their movements *must* have a different set of prices. Now the real system can admit of any other set of prices only if the distribution of income is allowed to change. We can work out all the price sets that are compatible with zero to the maximum wages for every supply set. If the set of the so-called market-prices imposed on the system at any given point of time happens to be one of those sets of prices, the system can accommodate those prices by adjusting its wages. But since these market-prices must change continuously it is more likely than not that the movement of market-prices will soon fall outside the set of the sets of all compatible prices for the given supply set. And at that stage the system must break down. In the above example we have allowed an arbitrary *numéraire* and the freedom to the system to adjust its income distribution to accommodate a given set of prices. If, however, we use the Standard commodity as the *numéraire* and specify wages in terms of the Standard commodity and keep them fixed throughout the adjustment process, then it is clear that the system cannot accommodate any other set of prices than its initial solution. In this context the very idea of any other set of market-prices as signals for quantity adjustment must break the system immediately.

All these conclusions must come as a shock to most economists. The reason for this is

simple. We are habituated to think of prices in terms of sequential time; such as at time t-1 a set of market-prices prevails and at those prices the set of inputs is purchased which in turn produces a set of outputs in time t. In this context the prices of inputs in time t-1 become the cost of production for the prices of outputs in time t. Not only is the classical gravitation mechanism built on this sort of reasoning about prices but even the modern inter-temporal general equilibrium analysis is also based on such reasoning even though it assumes that all present and future markets clear at one point of time. It was on the basis of such reasoning that Frank Hahn (1982) claimed that "It will now be clear that Sraffa is considering a very special state of the economy where … the relative prices of 1976 wheat and barley are the same as those of 1977 wheat and barley. The neoclassical economist is quite happy with more general situation." (pp. 363-64). As a matter of fact a simple observation of Sraffa's Standard system reveals why this way of thinking about prices is flawed (for a detailed criticism of Hahn's paper, see Sinha and Dupertuis 2009b and Sinha 2010a). Let us look at the example of Sraffa's Standard system presented above:

120t. iron + 160t. coal + 80qr. wheat + 1/4 labour → 240t. iron
40t. iron + 100t. coal + 120qr. wheat + 1/4 labour → 360t. coal **II**
40t. iron + 40t. coal + 200qr. wheat + 2/4 labour → 480qr. wheat

200t. iron + 300t.coal + 400qr. wheat + 1 labour → 240t. iron + 360t. coal + 480t. wheat

Assuming wages to be zero, it is clear that the maximum rate of profits in this system is equal to 1/5 or 20%. This is a physical property of the system independent of any prices. Any arbitrary set of prices as long as it is applied to both inputs and outputs is compatible with the physical property of the system. However, if we apply a different set of prices to the inputs and a different set of prices to the outputs, which is what one must do during the adjustment process described by the gravitation mechanism as well as Hahn's 'general situation', then clearly the maximum

rate of profits of the system will, in general, not be equal to 1/5. But this contradicts the physical property of the system. Thus input and output prices cannot be seen in a sequential time frame. Prices have only one function in the system and that is to consistently account for the given distribution of income at any point of time. It should be noted that these results are derived on two fundamental assumptions: (1) labour is homogenised by given wages and (2) wages are taken to be determined from outside the system. Sraffians now need to justify these two assumptions.

Conclusion

In this chapter we have highlighted the crucial role the notion of equilibrium plays in both the classical as well as the neoclassical theories of value—the determination of value is possible in both the traditions only when the condition of equilibrium of demand and supply is invoked. We have, however, also noted that in the classical tradition the need for the determination of value arises in the context of accounting for the distribution of income, which is taken to be given from outside the system of price determination. It is well known that the idea of mechanical 'equilibrium' did not sit well with the classicists, particularly with Adam Smith.[7] Adam Smith and other classicists were mainly concerned with the evolution of the economy over historical time, particularly the movements of various categories of income. Such concern for historical trends does not sit well with the notion of mechanical 'equilibrium' of forces, which is fundamentally static in nature.[8] But then the accounting of the various categories of income, whose trends they were interested in describing, required them to come to terms with the theory of value, which they could not solve without invoking the notion of equilibrium of demand and supply. Furthermore, the classicists insisted that the natural or the equilibrium prices are determined by the objective data of the economy such as the production techniques in use and the

[7] See Groenewegen (1982) and Rothschild (2001).
[8] See Groenewegen (1982).

distribution of income given from outside. In this context the psychological notion of demand has no role in determining the quantitative values of natural-prices. However, yet again, they found themselves in choppy waters as they had to invoke the arbitrary assumption of constant returns on the techniques in use as well as the psychological notion of ‘motives’ behind the workings of the equilibrating mechanism. In this paper we have shown that Sraffa was successful in dissolving both these problems. He showed that the theory of value of the classical tradition neither requires the notion of equilibrium of demand and supply and hence the assumption of constant returns nor any psychological notion of ‘motives’ for the determination of prices. The neoclassical tradition, on the contrary, brings psychology and the notion of equilibrium to the centre of their theory of value, but in their general theory the distribution of income is also determined simultaneously with prices and cannot be taken to be given from outside. Thus, following Sraffa, a clear line of demarcation can be drawn between the classical and the neoclassical theories of value and the problem for both the theories is to justify or negate the proposition that the distribution of income is independent of price determination.

References

Arrow, K. and G. Debrue. 1954. 'Existence of an Equilibrium for a Competitive Economy', *Econometrica*, 22: 265-290.

Arrow, K. and F. Hahn. 1971. *General Competitive Analysis*, Holden-Day: San Francisco.

Baldone, S. 2006. 'On Sraffa's Standard commodity: is it price invariant with respect to changes in income distribution?', *Cambridge Journal of Economics*, 30(2), pp. 313-319.

Bharadwaj, K. 1978. *Classical Political Economy and the rise to dominance of Supply and Demand Theories*, R.C. Dutt Lecture, New Delhi: Orient Longmans..

Boggio, L. 1992. 'Production Prices and Dynamic Stability: Results and Open Questions', *The Manchester School*, vol. 60 (3), pp. 264-294.

Duménil, G. and Lévy, D. 1985. 'The classicals and the neoclassicals: a rejoinder to Frank Hahn', *Cambridge Journal of Economics*, vol. 9, pp. 327-345.

----. 1987. 'The Dynamics of Competition: a Restoration of the Classical Analysis', *Cambridge Journal of Economics*, vol. 11 (2), pp. 133-164.

Dupertuis, M.-S. and A. Sinha. 2009. 'A Sraffian Critique of the Classical Notion of Centre of Gravitation', *Cambridge Journal of Economics*, 33, pp. 1065-87.

Eatwell, J. 1987. 'Competition, Classical', *The New Palgrave Dictionary of Economics*, London: Macmillan.

Flaschel, P. and Semmler, W. 1987. 'Classical and Neoclassical Competitive Adjustment Processes', *The Manchester School*, vol. 55 (1), pp. 13-37.

Franke, R. 2000. 'Optimal Utilization of Capital and a Financial Sector in a Classical Gravitation Process', *Metroeconomica*, vol. 51 (1), pp. 40-66.

Gale, David. 1963. 'A Note on Global Instability of Competitive Equilibrium', *Naval Research Logistics Quarterly*, 10: 81-87.

Garegnani, P. 1976. 'On a change in the Notion of Equilibrium in Recent Work on Value and Distribution: A Comment of Samuelson', in Murray Brown, Kazuo Sato and Paul Zarembka (eds.), *Essays in Modern Capital Theory*, Amsterdam: North Holland, pp. 25-45.

Garegnani, P. 1997. 'On Some Supposed Obstacles to the Tendency of Market Prices Towards Natural Prices', in G.A. Caravale (ed.) *Equilibrium and Economic Theory*, London and New York: Routledge.

Groenewegen, P.D. 1982. 'History and Political Economy: Smith, Marx and Marshall', *Australian Economic papers*, vol. 21 (38): 1-17.

Hahn, F. 1982. 'The neo-Ricardians', *Cambridge Journal of Economics*, vol. 6, pp. 353-374.

Harcourt, G.C. 1981. 'Marshall, Sraffa and Keynes: Incompatible Bedfellows?', *Eastern Economic Journal*, vol. VII (1): 39-50.

Hicks, John. 1937. 'Mr. Keynes and the Classics: A suggested interpretation', *Econometrica*, vol. 5 (2): 147-159.

Hicks, John. 1985. 'Sraffa and Ricardo: A Critical View', in *The Legacy of Ricardo*, (ed.) G.A. Caravale, New York: Basil Blackwell.

Hollander, S. 1973. *The Economics of Adam Smith*, Toronto: University of Toronto Press.

Hollander, S. 1979. *The Economics of David Ricardo*, Toronto: University of Toronto Press.

Hollander, S. 1992. *Classical Economics*, Toronto: University of Toronto Press.

Jevons, H.S. 1957 [1871]. *The Theory of Political Economy*, New York: Kelly & Millman, Inc.

Marx, Karl. [1867] 1977. *Capital vol.1*, New York: Vintage.

McKenzie, L.W. 1954. 'On Equilibrium in Graham's Model of World Trade and Other Competitive Systems', *Econometrica* 22: 147-161.

Mill, J.S. 1848. *Principles of Political Economy with some of Their Applications to Social Philosophy*, London: John W. Parker, West Strand.

Nikaido, H. 1983. 'Marx on Competition', *Journal of Economics*, vol. 43 (4), pp. 337-362.

Patinkin, Don. 1956. *Money, Interest and Prices*, Evanston (Illinois): Row, Peterson and Compagny.

Ricardo, David. [1821] 1951. *On the Principle of Political Economy and Taxation*, Cambridge University Press, Cambridge.

Rothschild, E. 2001. *Economic Sentiments Adam Smith, Condorcet and the Enlightenment*, Cambridge, Massachusetts: Harvard University Press.

Samuelson, Paul. 1978. 'The Canonical Classical Model of Political Economy', *Journal of Economic Literature*, 16, 1415-34.

Sinha, Ajit. 2010a. *Theories of Value from Adam Smith to Piero Sraffa*, Routledge: London, New York, New Delhi.

Sinha, Ajit. 2010b. 'In Defence of Adam Smith's Theory of Value'. *European Journal of the History of Economic Thought*, vol. 17(1), March 2010, pp. 29-48.

Sinha, Ajit. 2010c. 'A Note on Ricardo's Invariable Measure of Value'. *Cahiers d'économie politique*, N° 58, 2010, (Forthcoming).

Sinha, A. and Dupertuis, M-S. 2009a. 'Sraffa's System: Equal Rate of Profits and the Notion of Centre of Gravitation', *Journal of Economics and Business Organization*, 71, pp. 495-501.

Sinha, Ajit. and M.-S. Dupertuis. 2009b. 'Sraffa and the Question of Equilibrium', *Cahiers d'économie politique*, N° 56, pp. 91-100.

Smith, Adam. [1776] 1981. *An Inquiry Into The Nature And Causes Of The Wealth Of Nations Volume I*, Indianapolis: Library Fund.

Sonnenschein, Hugo. 1972. 'Market excess demand functions', *Econometrica*, 40: 549-63.

Sraffa, P. 1960. *Production of Commodities by Means of Commodities*, Cambridge University Press: Cambridge.

Sraffa, P. N.D. *Piero Sraffa Papers*, Wren Library, Trinity College, University of Cambridge.

Steedman, I. 1984. 'Natural Prices, Differential Profit Rates and the Classical Competitive Process', *The Manchester School*, vol. 52 (2), pp. 123-140.

Wald, Abraham. [1936] 1951. 'On Some Systems of Equations of Mathematical Economics', *Econometrica* 19: 368-403.

Walras, L. 1954. *Elements of Pure Economics* (4th definitive edition),W. Jaffé (ed.), Allen and Unwin: London.