

Was It a “Fatal Error”? Sraffa and Samuelson on Marshall’s Partial Equilibria Method

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A man of genius makes no mistakes.
His errors are volitional and are the portals of discovery.
—James Joyce, *Ulysses*

1. Introduction

Sraffa (1925) and Samuelson (1971) presented a strikingly similar analytical argument concerning the theoretical domain of Marshallian partial equilibrium models. Yet they reached radically different conclusions from their analyses. In 1925 Sraffa claimed that the methodology of partial equilibria drastically reduces the portion of reality that can be analyzed in a logically consistent way; in his final view he concluded that Marshall’s theory should be abandoned (Sraffa 1930). By contrast, Samuelson showed that partial equilibrium models may be used rigorously in some well-defined cases, and even in some slightly more general cases they

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History of Political Economy 56:2 DOI 10.1215/00182702-11055085
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produce results that are approximately true. The similarity of Sraffa's and Samuelson's analyses has not escaped the attention of many scholars such as Eatwell (1990), Garegnani (1990), Schefold (1990), and Panico (1991) in their exchanges with Samuelson. One of the present authors has tackled this issue in a yet-unpublished *lectio brevis* in Italian at the Accademia dei Lincei (Salvadori 2023).

An interpretative puzzle arises. Samuelson commented several times on Sraffa's 1926 *Economic Journal* paper, while for presumably linguistic reasons he never commented on the 1925 Italian article, which was translated into English only in 1998 (Sraffa [1925] 1998). He eventually considered the conclusion Sraffa reached in the first part of his 1926 *Economic Journal* paper an error (see Samuelson 1987, 1990a, 1990b, 1991) and did not change his view even when Eatwell (1990), Garegnani (1990), Schefold (1990), and Panico (1991) brought to his attention the fact that his and Sraffa's analyses were similar.

In this article we pursue the following aims.

1. We highlight similarities and differences between Sraffa 1925 and Samuelson 1971.
2. We reconstruct the evolution of Samuelson's thought concerning Sraffa's 1926 critique of Marshallian economics.
3. We obtain new insights from Sraffa's unpublished manuscripts about Sraffa's thought on the role and significance of the constant costs case within Marshallian economics.
4. We take account of a change in Sraffa's assessment of Marshallian partial equilibrium methodology that took place in the second half of the 1920s.¹
5. And we reconsider the previous debate on these issues in the light of unpublished documents that were not available at the time of the debate.

1. The evolution of Sraffa's thought from the 1925–26 papers to the 1960 book witnessed a "turning point" in the year 1927 (Garegnani 2005; Kurz and Salvadori 2005; the expression was actually coined by Garegnani). Such a turning point implied a drastic refocusing of Sraffa's overall research project (see the letter, dated January 11, 1928, sent by Sraffa to the General Board of Cambridge University, quoted in Garegnani 2005: 483) that led Sraffa, inter alia, to reconsider his assessment of Marshallian partial equilibrium methodology. Existing literature has extensively investigated the consequences of Sraffa's 1927 turning point in relation to *Production of Commodities*. To the best of our knowledge, the consequences of Sraffa's post-1927 assessment of Marshallian partial equilibrium methodology have never been studied in relation to his contribution to the 1930 *Economic Journal* symposium on increasing returns and the representative firm.

In particular, we claim that linguistic barriers and denied access to Sraffa's unpublished manuscripts kept at the Wren Library of Trinity College, Cambridge, prevented Samuelson from having a comprehensive view of the evolution of Sraffa's appraisal of Marshallian economics in the second half of the 1920s. Both Samuelson and Sraffa were aware of the fact that the set of assumptions required to make Marshallian partial equilibrium models logically consistent comes at significant theoretical costs; but they markedly differed in their assessments of such costs. Moreover, in the few years elapsing between "The Laws of Returns under Competitive Conditions" (1926) and "A Criticism [and Rejoinder]" (1930), Sraffa realized that the consequences of his critique of Marshallian economics were much more devastating than what he thought and wrote in 1926; but he failed to explicitly spell them out and warn his readers in a published contribution. This inevitably contributed to the subsequent misunderstandings of his thought, including those by Samuelson. Similarly, in 1971 Samuelson markedly changed his assessment of Sraffa's 1926 contribution. Finally, the debate between Samuelson on one side and those who were interested in developing Sraffa's contribution to the classical theory of value and distribution on the other (ourselves included) has not taken into due account both the full analytical consequences deriving from the presence of a "turning point" in Sraffa's thought (Garegnani 2005) and Sraffa's unpublished manuscripts kept at the Wren Library.

2. Samuelson 1971 versus Sraffa 1925 on Partial Equilibria

In this section we discuss Samuelson's 1971 analysis of partial equilibrium and identify similarities and differences with Sraffa 1925. In the introduction to a paper devoted mainly to international trade theory, Samuelson (1971: 1) reported that many textbooks and even scientific papers make use of Marshallian partial equilibrium supply and demand curves without any rigorous check of their logical consistency with a general equilibrium model. Accordingly, in that paper, he provided the "needed mathematical foundations for the rigorous partial-equilibrium handling of general equilibrium" (1). Actually, partial equilibrium is considered only in section 5 of the 1971 paper, and the analysis there proposed neglects the issue of increasing returns to scale. In this section Samuelson identified a case in which mutual interdependence among sectors is absent, and thus,

unsurprisingly, partial equilibrium supply and demand curves produce the same analytical results as a general equilibrium model.

It is not an overstatement to claim that section 5 of Samuelson 1971 tackles the same theoretical problem that was the focus of Sraffa's 1925 Italian paper, whose content was summarized in the first part of his 1926 *Economic Journal* article. The goal Sraffa pursued was to identify the assumptions needed to render a partial equilibrium model logically consistent, given the two constraints concerning the independence of the supply curve of a given commodity (i) from its demand curve and (ii) from the supply curves of other commodities. The problem Samuelson wanted to solve was the identification of the conditions that make a partial equilibrium model formally equivalent to a general equilibrium model. The absence of any interdependence between different sectors allows the theorist to bypass the problem of the simultaneous determination of economic magnitudes, typical of a general equilibrium model, and thus justify the *ceteris paribus* clause, typical of a partial equilibrium model.

Samuelson identified a stricter set of conditions than Sraffa since he delimited the problem more rigorously—recall that Samuelson (1971), unlike Sraffa (1925, 1926), ignored scale economies. In fact, not only did Samuelson assume that the scarce resources responsible for diminishing returns to scale are industry-specific—the very condition Sraffa (1925) had identified—but he added two more assumptions on the demand side, namely, (i) each consumer is characterized by an additive utility function and (ii) labor, and its counterpart, leisure, have constant marginal (dis)utility. The first assumption implies that all commodities, for each consumer, are normal and independent of each other so that any change in one price leaves the demand for the other commodities unchanged; hence demand curves are mutually independent. The second assumption implies that any change in labor employment in an industry leaves the wage rate unchanged. Both assumptions were already considered by Marshall (1920: chap. 3), although he expressed the assumption about the marginal (dis)utility of labor by means of an equivalent assumption about the marginal utility of money.²

2. We thank Aldo Montesano for bringing this point to our attention. At the time Sraffa was writing, such assumptions on the demand side were generally made (Stigler 1950a, 1950b; Moscati 2019: chap. 3). This fact may explain why Sraffa did not find these two assumptions identified by Samuelson worth mentioning.

Unlike Sraffa, who in 1930 eventually reached the conclusion that Marshall's theory should be discarded (Sraffa 1930: 93), Samuelson concluded his 1971 assessment of partial equilibrium with a conciliatory tone:

A rigorous model has been presented here. No attempt has been made to lighten the strong assumptions needed (as for example in the usual Marshallian rigmarole of postulating some "approximate" constancy of marginal utility). Although all the strong assumptions made here are needed if the partial-equilibrium diagrams are to be valid, many of the properties of the classical models . . . will be valid in much more general models that dispense with simple graphs and are definable by simultaneous equations. (Samuelson 1971: 18)

Samuelson's argument can be restated by assuming that there is a metric in the space of all possible sets of assumptions. For any given level of approximation there exists a neighborhood of the set of assumptions investigated by Samuelson such that for every set of assumptions belonging to this neighborhood partial equilibria can be used with a level of approximation less than or equal to the given one. According to our interpretation, although Samuelson, like Sraffa, acknowledged that increasing partial equilibrium supply curves have a limited empirical domain, he considered it worthwhile to investigate those cases in which partial equilibria can be used with a certain degree of approximation.

The year in which Samuelson published his paper on international trade was the same year in which the famous book by Arrow and Hahn (1971) on general equilibrium theory came out. In this book the concept of diagonal dominance was used to study the uniqueness and stability of general equilibrium (233–35, 292–96; see also Morishima 1952; Arrow, Block, and Hurwicz 1959).³ Diagonal dominance at a given set of prices holds when there is a positive combination of excess supplies at those prices such that the excess supply of each commodity is more sensitive to a change in its own price than to a change in all the prices of the other commodities, that is, the diagonal of the matrix of the sensitivities to change is dominant.⁴ The condition identified by Samuelson is an extreme case of diagonal dominance, in which for each commodity the

3. We thank Roberto Scazzieri for drawing our attention to the concept of diagonal dominance.

4. A formal definition would require the introduction of appropriate notation; we refrain from providing it.

price responsiveness of excess supply of the other commodities, that is, the elements outside the main diagonal, are all naught so that the matrix of the sensitivities to change is a diagonal matrix. It is well known that general equilibrium scholars have succeeded in demonstrating the uniqueness and stability of general equilibrium only in highly restrictive cases. Accordingly, the conditions identified by Samuelson to deal with partial equilibria are a fortiori to be considered extremely restrictive, since the neighborhood of the set of assumptions he investigated would in any case contain only cases of diagonal dominance. Indeed, a less restrictive assumption might be the following: “The scarce factor(s) of production responsible for diminishing returns to scale in one industry may be employed by other industries only in negligible amounts,” where “negligible” depends on the degree of approximation sought for. Such a relaxed assumption allows partial equilibrium analysis to be applied to the case of small variations in the quantities produced by the various industries.

To conclude our analysis of Samuelson 1971, differences between the historical contexts in which Sraffa and Samuelson published their contributions need to be stressed. In 1925, “Marshall was economics,” especially in the Anglo-Saxon countries (Robinson 1951: vii). Hence Sraffa was challenging the dominant paradigm, and, as his subsequent intellectual trajectory and his unpublished manuscripts show, he sought to develop an alternative paradigm, or, better, to reestablish the classical paradigm on firmer foundations. By contrast, in 1971, general equilibrium was economics, to paraphrase Joan Robinson, and the method of long-period equilibrium was discarded in favor of the intertemporal equilibrium method. Therefore, in 1971, Samuelson was defending a method of analysis that, although it was no longer at the frontier of research on pure theory, was nonetheless widely used for dealing with topics such as monopoly and oligopoly, price discrimination and product differentiation. This was the perspective followed by the subsequent literature. Advanced microeconomics texts, such as that by Mas-Colell, Whinston, and Green (1995: 316–25), introduce partial equilibrium and the topics treated by this method only after the presentation of an analysis similar to the arguments developed by Samuelson (1971). Hence, unlike Sraffa, Samuelson was trying to solve a problem—the compatibility between partial and general equilibrium methods—within the neoclassical paradigm, whose basic fruitfulness he never questioned.

3. Sraffa on Variable and Constant Costs

In this section we restate the logical structure of Sraffa's 1925–26 analysis of variable and constant costs in order to reveal the hidden root of some of Samuelson's misinterpretations. We have presented our interpretation of Sraffa's 1925–26 papers elsewhere (Signorino 2000, 2001; Freni and Salvadori 2013), so here we provide just a few remarks to recall the gist of the argument. In this section we focus on the reasons why Sraffa and Samuelson started from what to many commentators appears to be a common analysis, but eventually they went in different directions. In particular, we concentrate on the consequences of Sraffa's overall analysis, since Samuelson paid greater attention to the conclusions of the first part of Sraffa's 1926 paper, somewhat neglecting the latter's contribution to the 1930 *Economic Journal* symposium on increasing returns and the representative firm.

Sraffa's (1925) main target was to highlight the existence of irremediable logical tensions within the Marshallian partial equilibrium model of perfect competition. In what follows we distinguish the case of variable (increasing and decreasing) costs from that of constant costs.

With reference to increasing costs, the logical tension takes the shape of a trilemma:

- (i) nonspecific factors,
- (ii) the methodology of partial equilibria,
- (iii) increasing costs.

In short, Sraffa showed that

- the partial equilibria methodology and increasing costs can be reconciled only by giving up the hypothesis of nonspecific factors;
- nonspecific factors and increasing costs can be reconciled only by giving up the partial equilibria methodology; and
- the partial equilibria methodology and nonspecific factors can be reconciled only by giving up the assumption of increasing costs.

With reference to decreasing costs, Sraffa first recalled that, as acknowledged by Marshall himself, perfect competition is incompatible with internal economies, that is, firm-specific scale economies. Hence only scale economies external to each and every firm can be considered within a perfect competition model. Second, he highlighted the logical tension among

- (a) non-industry-specific scale economies, that is, scale economies simultaneously affecting the cost conditions of a plurality of industries,
- (b) the methodology of partial equilibria, and
- (c) decreasing costs.
 - Non-industry-specific scale economies can be reconciled with decreasing costs only by giving up the methodology of partial equilibria.
 - The methodology of partial equilibria can be reconciled with decreasing costs only by giving up the assumption of non-industry-specific scale economies.

In a nutshell, partial equilibrium perfect competition models can be applied only to the case of decreasing costs deriving from scale economies that are external to the firm but internal to the industry. A very narrow subset of real-world scale economies indeed!

To sum up Sraffa's 1925 views on the compatibility between Marshallian economics and the empirical phenomena of nonconstant costs, it can be argued that for Sraffa the empirically most relevant cases of nonconstant costs (those deriving from scale economies that are external to the firm but not internal to the industry and from nonspecific factors of production) cannot be analyzed within a partial equilibrium model.⁵ As far as the other cases of nonconstant costs are concerned,

- (1) firm-specific scale economies can be analyzed in a partial equilibrium model *if and only if* the assumption of perfect competition is dropped;
- (2) decreasing costs resulting from an increase in the size of a given industry can be treated within a partial equilibrium model *if and only if* the assumption of industry-specific scale economies is introduced; and, finally,
- (3) increasing costs resulting from a modification in the proportion between the quantities of constant and variable factors employed by a given industry can be treated within a partial equilibrium model *if and only if* the assumption of industry-specific factors of production is introduced.

5. As noted by Sraffa ([1925] 1998: 362), as far as external scale economies are concerned, Marshall himself, in *Industry and Trade*, admitted that they generally belong to a plurality of sectors, thus rendering the conditions needed for a rigorous employment of partial equilibrium models empirically irrelevant.

Let us now turn to constant costs. The logic of Sraffa's 1925 argument on the compatibility between Marshallian economics and constant costs in the presence of nonspecific factors of production may be reconstructed as follows. Constant costs within a given industry can arise *either* from the presence of a perfect balancing of the forces that generate increasing and decreasing costs (a case that Sraffa considered very unlikely) *or* from the absence of such forces. This second case may be treated in a logically consistent manner within a partial equilibrium model *if and only if*

- (α) the increase in the size of the industry under scrutiny is negligible (so that no significant scale economies obtain) and
- (β) the industry under scrutiny employs only a negligible fraction of the whole amount available of the nonspecific factor of production (so that no significant alteration in the market price of the nonspecific factor can occur).

In the light of our reconstruction, the main conclusion implied by Sraffa's 1925 analysis of constant costs within a partial equilibrium model in the presence of nonspecific factors of production is as follows. Marshallian theorists must choose to appeal *either* to the assumption of a perfect balancing of the forces leading to increasing and decreasing costs *or* to assumptions (α) and (β) above. It hardly needs to be stressed that both options are highly restrictive.

It may be noted in passing that, as far as constant costs are concerned, Pigou (1927: 192, 193) fully endorsed Sraffa's analysis:

I am forced to confine my study to commodities which individually employ so small a proportion of each of the several factors of production that no practicable changes in the scale of their output could sensibly affect the relative values of these factors. . . . Hence, with this class of commodity, it is *impossible* for production anywhere to take place under conditions of increasing costs. In this matter my conclusion agrees with that reached by Professor Sraffa in his recent article.

From Sraffa's 1925–26 analysis of the state of economic theory a bleak picture emerges. The general equilibrium approach is characterized by a complexity that “prevents it from bearing fruits at least in the present state of our knowledge” (Sraffa 1926: 541). The partial equilibrium approach may be used to analyze only two empirically irrelevant cases of nonconstant costs (increasing costs arising from specific factors and diminishing costs arising from scale economies that are external to the firm and

internal to the industry) and to analyze the case of constant costs when there is a perfect balancing of the opposing forces of increasing and decreasing costs or when assumptions (α) and (β) hold. These considerations may seem sufficient to justify Sraffa's trenchant 1930 claim that Marshall's theory ought to be discarded. Yet, in 1925 and 1926, for Sraffa, a choice has to be made among the first-approximation models available: Sraffa in the first half of the 1920s did not consider the option of discarding the whole corpus of existing theoretical economics and starting anew from scratch. His choice fell on "the old and now obsolete theory which makes it [the problem of competitive value] dependent on the cost of production alone," which he aptly defined as a simple theory that *cannot* be used in a second approximation to reality and that is chosen *only* because it was, in his opinion, the best among the available alternatives (see Sraffa 1926: 541).

Hence, Samuelson (1971) and Sraffa (1925, 1926) were aware that the methodology of partial equilibria is incompatible with the analysis of the various empirical phenomena entailed by sector interdependences and identified a similar set of assumptions required to neutralize such interdependences in order to make partial equilibrium models workable. Yet, they proposed different answers to the question on how and when one actually could make use of a logically reconstructed partial equilibrium model.

Samuelson in his *Foundations* clarified that for every choice a price must be paid, and choices among alternative assumptions in the activity of model-building are no exception to the rule:

It is clear that every assumption either places restrictions upon our empirical data or is *meaningless*. A price must be paid for any simplifications introduced into our basic hypotheses. This price is the limiting of the field of applicability and relevance of the theory because of the extra empirical restrictions to be imposed on the data. Many writers do not appear to be aware of this; in any case few have indicated the costliness of their assumptions or have adduced any evidence to support a presumption of their admissibility.

There is a further serious difficulty. Despite the fact that . . . mathematical methods of exposition have been employed, ambiguity still permeates the contentions of many writers. This ambiguity can go unnoticed precisely because there has been so little interest in the operational significance of these assumptions. To put the matter somewhat

harshly, ambiguously defined assumptions are used to give a semblance of deriving theorems which are themselves inconclusive. (Samuelson 1947: 172)

In the mid-1920s Sraffa appears to have thought that, with reference to partial equilibrium models, the constant cost assumption when both conditions (α) and (β) hold entails a lower theoretical price than the variable cost assumption. If that is the case, it must be admitted that Sraffa changed his mind a few years later. We claim that such a change is a by-product of the fact that in 1927 Sraffa started to draft the first equations that eventually led to *Production of Commodities by Means of Commodities*. The rediscovery of a distinct classical theory of value and distribution and the elaboration of the equations shown to Keynes and Pigou in 1928 must have implied also a different attitude with respect to Marshallian partial analysis. With the benefit of hindsight, Sraffa's trenchant 1930 claim that Marshall's theory ought to be discarded should not be surprising to readers of the 1960 book.

4. Samuelson on the First Part of Sraffa 1926 Before and After 1971

In this section we reconstruct the evolution of Samuelson's thought on Sraffa's 1926 paper and show that after his 1971 paper he significantly changed his mind on the validity of Sraffa's assessment of the constant cost case within a Marshallian partial equilibrium model. Samuelson discussed the constant cost case essentially along Sraffa's 1926 (and Pigou's 1927) lines in some of his writings before 1971, while in several subsequent contributions, in evaluating Sraffa 1926, he clearly distinguished the first part (dedicated to the critical reconstruction of the Marshallian partial equilibrium model) from the second (in which the foundations of the theory of monopolistic competition are laid). As far as the second part of Sraffa 1926 is concerned, Samuelson's judgment is flattering and did not significantly change between the pre- and post-1971 contributions. According to Samuelson ([1967] 2014), perfect competition theory fails both the realism-of-assumptions test and the accuracy-of-predictions test. Accordingly, economists who adopt a methodology à la Friedman 1953 should acknowledge that "the perfect-competition model fails to be an adequate approximation" (Samuelson [1967] 2014: 415n5). On the other hand, with reference to the first part of Sraffa 1926, Samuelson declared after his 1971 paper Sraffa's analysis of constant costs in a partial

equilibrium model as an error. In what follows we provide the details of Samuelson's change of mind.

In the seventh edition of his *Economics: An Introductory Analysis*, Samuelson (1967: 428) wrote as follows:

When a large industry (which has already achieved the economies of large-scale production) expands, it must coax men, ships, nets, and other productive factors away from other industries by bidding up their prices and thus its cost. So the long-run supply curve s_L, s_L will usually be sloping gently upward. . . . Only if the industry is small compared with the total of all other users of its factors will Marshall's s_L, s_L curve . . . be horizontal—which is called the case of “constant cost.”

While Sraffa and Pigou are not mentioned in the 1967 textbook (which is understandable, given the didactical nature of the book), in the same year, in “The Monopolistic Competition Revolution” (Samuelson [1967] 2014), a contribution to a Festschrift in honor of Edward Chamberlin, Samuelson pointed out that

Piero Sraffa's justly famous 1926 article takes on a new light in terms of this analysis of the Marshallian influence. Truly reversible decreasing cost industries associated with external economies are perhaps a *curiosum*. If a competitive industry is small, and to the degree that it uses no specialized factors in intensities different from that of the bulk of the rest of industry, it does tend to fall in the category of *constant costs*. We can agree with Sraffa on this. (Samuelson [1967] 2014: 422; the emphasis in the final sentence is ours)

Samuelson's reference to the degree in which nonspecialized factors are employed in different industries clearly echoes the analysis developed in Robinson 1941, a paper quoted with approval by Samuelson in his *New Palgrave* entry on Sraffian economics (see below). As we show in the following section, Sraffa, in the lectures he gave on “advanced theory of value” in 1928–31—lectures that were attended by Joan Robinson—presented an argument similar to the one developed by the latter about ten years later.

No further traces of agreement with Sraffa on the constant costs issue are to be found in Samuelson's contributions after 1971.

In the *New Palgrave* entry titled “Sraffian Economics” and especially in the section titled “1926 Reconsidered from 1960,” Samuelson (1987) praised the second part of Sraffa 1926 in which Sraffa clarified the incompatibility between economies of scale within a single firm and perfect

competition and paved the way toward the theory of imperfect competition. Regarding the first part of Sraffa 1926, Samuelson (1987: 458) wrote as follows:

Within the mid-1920s, Sraffa's other thesis generated a disproportionate amount of interest. Not only was the familiar downward-sloping Marshallian supply curve to be ruled out as incompatible with perfection of competition; the young Sraffa was newly arguing that upward-sloping supply curves were also of vacuous importance for Marshallian partial equilibrium. All that Sraffa left his reader, then, was a horizontal, *constant-cost* competitive supply curve.

This is plain wrong. Sraffa's 1960 book demonstrates that when primary factors other than a single homogeneous labour exist, rightward shifting Marshallian and Walrasian demand curves will generally trace *rising* price intersections on the relevant supply curves.

Samuelson continued by introducing a reference to Robinson 1941:

Joan Robinson's famous 1941 *Economic Journal* article on rising supply price was the first East Anglian recognition of the formal comparative statics of general equilibrium.⁶ I doubt that she or Piero ever noticed the incompatibility with 1926 Sraffa; or the incompatibility of Heckscher–Ohlin and Stolper–Samuelson in the foreign-trade literature with Sraffa's thesis of *constant* costs and implied *linear* production-possibility frontiers. (Samuelson 1987: 458)

In his contribution titled "Revisionist Findings on Sraffa" to the conference held in Florence in 1985 to celebrate the twenty-fifth anniversary of the publication of *Production of Commodities*, Samuelson (1990b) devoted a section to "the fatal 1926 error" in which he compared his *New Palgrave* entry on Sraffian economics with the biographical entry by Eatwell and Panico (1987) on Sraffa himself:⁷

6. Samuelson makes a small slip here. The actual source of Robinson's paper is *Economica*.

7. One of the referees was puzzled by the fact that in 1985 Samuelson compared two *New Palgrave* entries published in 1987. Some words of explanation are in order. In the preface of the book published in 1990 we read as follows: "Some [papers] have been added later, notably that of Professor Samuelson who had been unable to attend the conference. The discussions continued and are reflected in comments and replies submitted until the autumn of 1988" (Bharadwaj and Schefold 1990: ix). In private correspondence, Professor Schefold informed us that the proposal to combine contributions by participants of the conference and nonparticipants was advanced by Professor Garegnani; the editors went along with the proposal, and, in Schefold's own words, "it turned out to be successful."

The two *Palgrave* articles are diametrically different in their evaluation of the 1926 article on competitive returns that brought Sraffa early fame. Both of course agree with his critique of Marshall's attempt to paper over the incompatibility of a firm's falling marginal cost with perfect competition. Helping 1920s Cambridge catch up to 1838 Cournot was a valuable, needed, Sraffian contribution, which did stimulate Joan Robinson and Kahn to those imperfect competition advances that paralleled the contemporary American work of J. M. Clark and Chamberlin. No argument on this. But on the other half of the 1926 classic—Sraffa's purported demonstration that the category of *constant* competitive cost constitutes the only empirical box with appreciable content—the *Palgrave* articles are 180° apart.

It is clear that Samuelson thought that the goal pursued by Sraffa in his 1925–26 papers was to demonstrate that the assumption of constant costs ought to be adopted and not that “Marshall's theory should be discarded.” Samuelson continued:

I state, “This is plain wrong. Sraffa's 1960 book demonstrates that . . . [as does] Joan Robinson's famous 1941 *Economica* article on rising supply price. . . .” As soon as two competitive goods involve different land/labour proportions, the *production possibility* frontier is curved and not straight in the fashion Sraffa needs. . . . Sraffa by pure rhetoric convinced himself and my generation of students of a simple error. I reproach myself that, for a dozen years, I was taken in and passed on to students defective reasoning and conclusions. When I reread the 1926 article with a magnifying glass, I perceived it to be blue smoke: Sraffa does not even purport to provide a cogent proof of anything—by suggestion, and implicit appeal to what is legitimate in (Marshallian) *partial* equilibrium methodology, the cases where alterations in composition of demand alter competitive price ratios are minimized. This is not even good Ricardo! (Samuelson 1990b: 93–94)

Samuelson could not know, of course, that Sraffa had anticipated the theoretical nucleus of “Joan Robinson's famous 1941 *Economica* article” in his 1928–31 lectures (see below), which Joan Robinson and Richard Kahn attended. Moreover, the wording of Sraffa's 1926 paper leads to misunderstandings. To support his position, Samuelson recalled his 1971 paper:

I here present an impeccable Marshallian model in which (a) each of n goods is produced by transferable labour and a specialized land specific to itself, (b) every person's demand function for each of the n goods is strictly independent of every other good's price or quantity (strongly additive independent utilities), (c) for every person the marginal disutility of labour is a strict constant ("objectively" identifiable from market data). The example glaringly contradicts Sraffa's constancy of costs and obeys *all partial* equilibrium requirements (at the same time that it is a *full* general equilibrium model, a congruence Alfred Marshall never quite achieved). See Samuelson (1971), for more on such a rigorous partial equilibrium as applied to trade theory. (Samuelson 1990b: 94)

In the following year, in his reply to Panico (1991), Samuelson made explicit reference to what "Sraffa may have written in his 1925 Italian text but failed to summarise in 1926 for reasons of space" (Samuelson 1991: 573) and to Sraffa's 1930 exchange with Dennis Robertson. The latter is discarded since Sraffa himself (1930: 89) had written that "the following comments . . . refer only to . . . the problem of increasing returns." But he felt the need to change his attack: "Having now read the detailed charge, reread my cited works and the basic documents, I believe the jury will be grateful for a new airing of the issues but will conclude with an even more damning verdict than I had occasion to recommend in my indictment" (Samuelson 1991: 570). And he added:

My fundamental point, let it now be clear, was that Piero Sraffa sought to have but one leg to stand on. Competitive prices, everyone now knows, must stand squarely on the two legs of (i) tastes, desires, needs and distribution of endowments (in short, on *consumer-demand* factors), and (2) technology and production costs. At one time or another, Adam Smith (very briefly), David Ricardo, and Frank Knight (briefly), have tried to concentrate on subcases of reality where competitive prices (price ratios, and goods prices relative to factor prices) can be determined *autonomously* in terms of technology and costs alone: the one-leg case. What is consistent throughout the lifeline of Piero Sraffa—in 1925, 1926, between 1926 and 1930, in 1951 and 1960+—is the attempt to emphasise the singular cases in which the theory of value happens to be dependent only on technology and costs independently of the composition of demand. (570)

Finally, in his reply to Kurz and Salvadori's comments on his essay "Sraffa's Hits and Misses," Samuelson, after recalling his 1971 contribution, wrote as follows:

The example's result is rising *ss* curves for all goods, intersecting in a Marshallian cross with the goods' declining *dd* curves. QED. Any shift in tastes from one good to another raises the relative price of that one good. QED. What was half the fuss about in 1926? Often when I beat down resistance to this line of argument, at the end of the day I would be told: "Well yes. And somewhere in the Italian 1925 version or the English 1926 version there are Sraffian words that do say this." If so, Amen. (Samuelson 2000: 168)

This response echoes the one given to Garegnani in his reply to the latter's comments about Samuelson 1990b:

A new point here is that, in Sraffa's longer Italian version of 1925, he is said to have endorsed my position—namely that, as a matter of exact logic, the box of increasing-cost, rising supply is not empty even in an impeccable partial equilibrium model. (Wheat and wine use respective lands specialized for them.) Two people seem to deserve congratulations: Piero Sraffa and I. How was one to know in the Viner or Schumpeter seminars of 1934–5 that the 1926 author knew better than he wrote? The many merited reprints of the 1926 classic never carried author's alterations to warn of this. (Samuelson 1990a: 320)

As argued in section 2 above, in the 1971 paper Samuelson demonstrated that, in order to rigorously employ the partial equilibrium method, all interdependences between sectors must be avoided. To this end, both the utility functions and the production functions of the various commodities must have well-defined formal properties: as far as the demand side is concerned, individual utility functions must be additively separable and all consumer goods must have decreasing marginal utility, while labor, the only nonspecific factor of production, must have constant marginal disutility; with reference to the supply side, every commodity must be produced by means of specific factors (different qualities of land) and one homogeneous and fully mobile factor (labor). These functional forms identify for each commodity a negatively sloped demand curve and a positively sloped supply curve.

Thus, after 1971 Samuelson had no doubt that the partial equilibrium model was incompatible with the case of constant costs. In his 1971 paper,

constant costs are obtained *if and only if* all commodities are produced by labor alone, that is, without any sector-specific scarce factor such as Samuelson's "lands." Such a case may seem *highly* unrealistic since intermediate goods are not considered. Samuelson (1971: 13n) mentioned intermediate goods and argued that "one can admit capital goods in this model in the Von Neumann–Leontief fashion provided all intermediate goods used in any industry are producible from labor and the specific lands of those industries." Hence intermediate goods must also be industry-specific. But in the case of constant costs, if intermediate goods are produced by labor and other intermediate goods produced without making use of any industry-specific land, then they do not need to be industry-specific.

In the light of our interpretation of the different conclusions reached by Sraffa (1925) and Samuelson (1971) on the partial equilibrium methodology, it may be claimed that, for Samuelson (1971), the "price" the theorist has to pay by making use of the factor specificity assumption is lower than the "price" paid by the assumption of constant costs. Hence, it makes perfect sense for Samuelson post-1971 to call a "fatal error" Sraffa's conclusion that the assumption of constant costs in a partial equilibrium model is the best first-approximation available.

We would like to point out that at the root of Sraffa's and Samuelson's different assessments of the "relative price" of the various assumptions within partial equilibrium methodology lie Sraffa's and Samuelson's different assessments of general equilibrium models. Sraffa (1926: 541) considered the general equilibrium models he knew (mainly Pareto's) as logically rigorous but empirically sterile, also following, in this respect, Ricci 1924 (on Pareto's influence on the Italian economists through the *Giornale degli Economisti*, see McLure 2007: chap. 4). Samuelson, on the contrary, considered general equilibrium models as the theoretical benchmark on which any valid economic model must be founded.

In the 1967 monopolistic competition revolution paper, Samuelson ([1967] 2014: 420) first stated that "if there is a proper understanding of general equilibrium, it is possible to attain for the first time an understanding of partial equilibrium" and then criticized Sraffa on one point:

Such cases [the case in which the industry uses some factors of special advantage to it alone or in which it uses the various factors of production of society in proportions significantly different from the rest of industry] create absolutely no complications for general equilibrium,

even though Sraffa may be right in thinking they do for partial equilibrium (in which case, so much the worse for partial equilibrium analysis, Marshallian or otherwise!). The point needing emphasis for Sraffa's readers is that these phenomena and complications do not themselves create a need for monopolistic competition theory. Where that theory is needed is in handling genuine empirical deviations from perfect competition. *Mere interdependence of essentially competitive industries should have led Sraffa merely to a plea for abandonment of Marshallian partial-equilibrium models in favor of Walrasian general-equilibrium models.* (422–23; emphasis added)

Accordingly, it may be claimed that, for Samuelson, Sraffa's original sin concerning the compatibility between constant costs and partial equilibria derives from Sraffa's reluctance to embrace wholeheartedly the general equilibrium approach whenever the issue of sectors' interdependence could not be bypassed.

5. The 1928–31 Lectures on Advanced Theory of Value

In the previous section we have reconstructed the evolution of Samuelson's view of Sraffa 1926, particularly on the issue of constant costs within Marshallian economics. We claimed that the main reason for disagreement lies in the two scholars' different evaluation of the relative price of the assumptions, constant costs versus specific factors, required to make a partial equilibrium model logically consistent with a general equilibrium model. We have also argued that such a difference stems most likely from the fact that Samuelson and Sraffa thoroughly disagreed on the relevance of neoclassical general equilibrium models. Clearly, Samuelson in his appraisal of Sraffa's 1926 paper did not take into consideration Sraffa's unpublished manuscripts. From this material it emerges that Sraffa's thought evolved significantly from his initial assessment of Marshallian economics toward a rediscovery of a distinct classical approach to the theory of value and distribution (Garegnani 2005; Kurz and Salvadori 2005; Kurz 2023). In what follows we focus on the 1928–31 lectures on "advanced theory of value" (D2/4).⁸ As recalled

8. Sraffa's manuscripts are cited according to the catalog prepared by Jonathan Smith, archivist, Wren Library, Trinity College, Cambridge. They are available at <https://www.trin.cam.ac.uk/library/wren-digital-library/modern-manuscripts/piero-sraffa/>.

by Joan Robinson (1951: vii), “Mr. Sraffa’s lectures were penetrating our insularity. He was calmly committing the sacrilege of pointing out inconsistencies in Marshall (his article of 1926, . . . also, was still reverberating) and at the same time revealing that other schools existed (though they were no better) [the “other schools” Joan Robinson refers to are most probably the Austrian school and the Lausanne school of Walras and Pareto, given the space devoted to them by Sraffa in his lectures].” The analysis of this unpublished material provides compelling evidence that Samuelson’s criticism concerning Sraffa’s “errors” is unfounded. In particular, the surviving text of the 1928–31 lectures shows that

- Sraffa already had first-hand knowledge of Pareto’s version of the general equilibrium approach,
- Sraffa’s criticism of Marshall was based on a general equilibrium approach, and
- Sraffa had covered the core of Robinson’s 1941 article in the course of a lecture in 1929.

To show this, let us begin with a long quotation.

Let us suppose a very simple case. A number of different commodities are produced by two factors of production, say land and labour: we assume that some quantity of both factors is necessary for any product, but their proportions may be varied: we also assume that all the units of land are of uniform quality, and also the units of labour. The condition of equilibrium, of course, will be that the value of the marginal product of labour should be equal in all the industries, also the marg. prod. of land (i.e. wages + rents in *value* uniform).]

In this position of equilibrium, there is no reason to suppose that land and labour will be employed in the same proportions in all the industries: in some of them a large number of men will be employed on an acre of land, in others a small number. . . .

Now suppose that in this state of equilibrium there is an increase in the demand for one of the products. How will the value of the product be affected? Since D.R. [decreasing returns] are obtained from each of the factors it might seem that its value will increase. But this does not follow.

Information regarding the raising of the demand curve for a product is not sufficient to tell us what will happen to its price. It all depends upon the source-origin cause of the change in demand.

We may distinguish two [i.e., three] cases:

- 1) due to change of tastes of consumers,
- 2) due to increased supply of one of the factors (this includes improvements+inventions)[, and]
- 3) improvements+inventions[.]

If increased demand for one product is due to change in taste, this means that the demand for another product must have decreased to the same extent: since the total demand for all products is the same as the supply of factors (all product is divided between factors of production). The total demand cannot increase if the supply of factors is unchanged.

It all depends upon whether

1. the commodity the demand for which is increased is produced by a higher or lower proportion of labour per unit of land as compared with the commodity the demand for which falls, and
2. the commodity in question is produced by a higher or lower proportion of labour per unit of land as compared with the average of all commodities (or with the commodity which we select as a standard of value).

Make an example: *cabbages* (high proportion of labour), *wheat* (low proportion of labour).

Suppose demand for cabbages rises, and for wheat falls. Land and labour will be transferred to cabbages: but so long as the proportions remains unchanged, a part of the land will be unemployed.

Then this land will be spread over all the industries until its marginal product has fallen all around. Then, the value of all the products which are produced by much land (e.g. wheat) will fall as compared with the price of those produced by much labour.

Note that:

- 1) if the change in demand is from one product to another both of which have *equal proportions* of labour and land, all values will remain unchanged,
- 2) if the proportions are different, the value of the article the demand for which increases will *always rise* in terms of the article the demand for which falls: but it may fall in terms of all other articles. (D2/4, pp. 129–30, 131–33)

The above quotation shows that Sraffa, at least in 1929,⁹ was aware of the fact that, when the simultaneous production of various commodities

9. One of the referees suggested that we consider the possibility that Sraffa's acquaintance with Pareto's general equilibrium theory was broader in the 1928–31 lectures than it was in the

is investigated, the constant cost case *strictly* applies *only* when commodities are produced with a uniform ratio of the two factors of production considered, land and labor. In the general case where the land-labor ratio is different between sectors, any change in consumers' preferences will *inevitably* lead to a change in relative prices. Note that initially Sraffa speaks of capital and labor, while subsequently he speaks of land and labor, that is, he replaced a produced factor of production with a nonproduced factor of production.

Readers of Robinson 1941 will immediately recognize the similarity of the analysis. Joan Robinson distinguished between two scenarios: what she called the “Marshallian” scenario of a net increase in the overall demand for n commodities (the demand for a given commodity—commodity alpha to use Robinson's example—increases while the demand for the other $n - 1$ commodities remains unaffected) and the scenario of a change in the consumers' relative preferences between a given commodity alpha and the remaining $n - 1$ commodities. The distinction is relevant since full employment of all factors of production is assumed throughout. In the “Marshallian” case the increase in alpha production resulting from an increase in the demand for alpha, *ceteris paribus*, can occur if and only if the increase in demand for alpha leads to an increase in the overall economy-wide available amounts of labor and capital goods (land and natural resources are assumed to be given and constant). Such an increase should be sufficient to bring about the required increase of alpha production. By contrast, the non-Marshallian case of a change in the relative consumers' preferences entails that (i) the overall economy-wide available amounts of labor and capital goods remain constant, (ii) the demand for a given commodity, alpha, increases, (iii) the reduction in demand for the $n - 1$ commodities is small compared to the increase in demand for alpha, and (iv) the factors of production are reallocated from the $n - 1$ sectors, whose demand has decreased, to the production of alpha, whose demand has increased. In this second scenario, relative commodity prices remain constant, and alpha production takes place in

1925–26 papers. While we acknowledge that it is a possibility worth considering, this is not the place for a careful examination of the issue. As noted by Kurz (2020: 175), Sraffa was familiar with the writings of Vilfredo Pareto long before 1927, although it is true that he “significantly consulted the *Manuale* in November 1927 and *Les systèmes socialistes* in early 1928” (Kurz 2023: 32). Accordingly, our very provisional answer is that Sraffa did not significantly change his assessment of Pareto's point of view as a viable way to fill the empty boxes of economic theory with empirical content.

a constant costs regime if and only if alpha production requires factors of production in exactly the same proportion as they are used in the remaining $n-1$ sectors. Conversely, to the extent to which alpha production employs factors of production in a different proportion than the other $n-1$ sectors, an increase (decrease) in the equilibrium price of factors that the alpha sector employs in a higher (lower) proportion than the average will follow:

We cannot say whether or not the supply price of alpha rises with an increase in its output until we know how prices are to be reckoned. The obvious solution is to measure prices in terms of a composite unit of resources, the factors being weighted by the proportions in which they are found in industry as a whole. So long as we are assuming a fixed supply of each factor this measurement is quite unambiguous. Now, the factors which alpha requires, or requires most, have risen in price in terms of the composite unit, while the factors which it does not require, or requires least, have fallen in price. Thus the supply price of alpha rises in terms of the composite unit, while the supply price of all other commodities falls, each a little. *Thus, for any commodity considered separately there is rising supply price, because an increase in the output of any commodity turns the relative factor prices against itself.* (Robinson 1941: 5; emphasis added)

Robinson concluded that, given the overall economy-wide available amounts of labor and capital goods, the increase in the relative price of alpha will be all the more significant the “larger” the alpha sector is in relation to other industries, the more idiosyncratic the relationship between the factors of production, and the lower the elasticity of substitution between the factors of production in the production of alpha. Joan Robinson’s analysis thus provides further support for Sraffa’s argument in his 1928–31 lectures (and for the arguments in Pigou 1927) that, in the presence of nonspecific factors of production, the theoretical domain of a partial equilibrium perfectly competitive model is confined to the case of a small increase in the output of a commodity that employs only a small portion of the economy-wide amount of the factors of production so that the resulting increase in costs may be neglected (at least in a first-approximation model): “For the general run of manufactured commodities, on the other hand, in the perfectly competitive world postulated by our assumptions, almost constant supply price would be the general rule” (Robinson 1941: 8; emphasis added).

As his *New Palgrave* entry on Sraffian economics shows, Samuelson approved Robinson's 1941 argument. Not having access to Sraffa's 1928–31 lectures, Samuelson could not know that Joan Robinson in her 1941 article took her cue from and actually developed a line of analysis Sraffa had sketched in his lectures.

In the 1928–31 lectures Sraffa did not place emphasis on the case of constant costs. In the passages in which Sraffa mentioned constant costs, it seems that his intention was not to state that constant costs are the empirically most relevant ones, at least as far as a first-approximation model goes: for Sraffa, the empirically relevant cases are those that cannot be analyzed by the perfect competition model (internal economies) or the partial equilibrium method (non-industry-specific factors and non-industry-specific scale economies). On the other hand, in the few passages in which he mentioned constant costs, Sraffa is clearly motivated by the intention to criticize the then mainstream explanation of constant costs as a perfect balance of the opposing tendencies to increasing and decreasing costs. Sraffa's position could be rationalized in the following terms: Marshallian economists usually present constant costs as the empirically exceptional case of a perfect balancing of opposing nonconstant cost tendencies. In doing so, they ignore the possibility that constant costs may result from the absence of both causes of variable costs. For Sraffa, the explanation of constant costs in terms of a perfect balancing of variable costs clashes with the fact that the most empirically relevant cases of variable costs do not fall within the scope of the Marshallian model. Thus, the case of constant costs is empirically as exceptional as the case of increasing costs due to a specific factor and the case of decreasing costs due to scale economies external to any firm and, at the same time, internal to a given sector. If one is looking for an explanation of constant costs in the context of the Marshallian model, Sraffa appears to be saying, then the most plausible explanation is the simultaneous absence of the causes of increasing and decreasing costs rather than the presence and perfect balance of both:

We see therefore that in both dim. + incr. can be applied only to a relatively small number of cases. All the cases which are excluded, i.e. all ind. which are not subject to incr. or decr. ret. in a sense in which they may be taken account of in the sup. curve, naturally fall in the class of constant costs. It seems a fairly obvious conclusion that when no tendency of which we may take notice to change operates, cost must be

regarded as constant. It is therefore curious to find that all the economists who attach a great importance to the symmetry between $S + D$, suppose that c.c. may arise, not from the absence of any tendency to change, but only from the accidental balancing of the two opposite tendencies. (D2/4, p. 158)

Let us conclude this section with another interpretive puzzle: Samuelson appreciated Robinson 1941 while he did not spare Sraffa charges of errors for his position on constant costs, despite the fact that Robinson's and Sraffa's (and Pigou's [1927]) positions on constant costs are basically the same. In our view, this might be connected to the unfortunate wording of the 1926 text, which invited misunderstandings—misunderstandings that Sraffa himself was aware of, as his June 1926 letter to Keynes shows:

I have . . . tried to argue that Marshall's premises are, in general, consistent only with constant returns. This conclusion has been misunderstood and taken to imply that in actual life constant returns prevail: although I believe that Ricardo's assumption is the best available for a simple theory of competition (*viz.* a first approximation), of course in reality the connection between cost and quantity produced is obvious. It simply cannot be considered by means of the system of particular equilibria for single commodities in a regime of competition devised by Marshall. Some of such connected variations must be regarded as part of simultaneous equilibrium of all industries (Pareto's point of view). For others, perhaps the most important, it must be recognized that the assumption that perfect competition may be taken as a hypothesis well representative of the multiplicity of independent producers, is untenable. (D3/6, 2.f.4 r.)

6. Final Remarks

In this article we have reconstructed the evolution of Sraffa's and Samuelson's thought on Marshallian partial equilibrium analysis. In Sraffa's case, we have made use of published works and unpublished manuscripts to which Samuelson did not have access during his lifetime. In our view Sraffa's unpublished papers in the Wren Library are of fundamental importance to the task of comparing the two scholars' contributions to the issue under investigation. We have highlighted that, if we

restrict our analysis to Sraffa 1925 and Samuelson 1971, the analytical contributions of the two scholars are similar, and the different conclusions they reached have their origin in their different evaluation of the “relative price” of the assumptions required for a rigorous formalization of the Marshallian theory. If we look at Samuelson’s post-1971 critique of the first part of Sraffa 1926, much of the contrast with scholars such as Eatwell, Garegnani, Panico, and Kurz and Salvadori, who were interested in developing the classical theory of value and distribution along the lines of Sraffa 1960, is partly explained by the unfortunate wording in Sraffa 1926. Moreover, both parties in the debate, although for different reasons, did not fully consider the analytical consequences of the fact that Sraffa significantly changed his assessment of the fruitfulness of the Marshallian partial equilibrium approach in the second half of the 1920s: in 1926 he was still wondering what could be saved of Marshall’s theory, while in 1930 he claimed that Marshall’s theory should be discarded.

In private conversation, Edwin Burmeister pointed out to us that Marshall, Sraffa, and Samuelson had different models, all of which “portray, though perhaps in a distorted manner, some of the features of the real world,” as Mark Kac (1969: 699) put it.¹⁰ If one takes the view that they were addressing different questions, then one might surmise that none of them made an error. However, even if one takes the opposite view that errors have been made, we often learn more from errors made by men of genius than from some correct results achieved by mediocre scholars, as James Joyce reminded us.

References

- Arrow, Kenneth J., H. D. Block, and L. Hurwicz. 1959. “On the Stability of the Competitive Equilibrium.” Pt. 2. *Econometrica* 27, no. 1: 82–109.
- Arrow, Kenneth J., and F. Hahn. 1971. *General Competitive Analysis*. San Francisco: Holden-Day; Edinburgh: Oliver & Boyd.
- Bharadwaj, K., and B. Schefold. 1990. Preface to *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, ix–x. London: Unwin Hyman.
- Burmeister, E. 2009. “Reflections.” In *Robert Solow and the Development of Growth Economics*, edited by Mauro Boianovsky and Kevin D. Hoover. *History of Political Economy* 41 (supplement): 35–43.

10. More on this in Burmeister 2009: 42.

- Eatwell, J. 1990. "Comment." In *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, 280–83. London: Unwin Hyman.
- Eatwell, J., and C. Panico. 1987. "Piero Sraffa (1989–1983)." In *The New Palgrave: A Dictionary of Economics*, edited by J. Eatwell, M. Milgate, and P. Newman, 4:445–52. London: Macmillan.
- Freni, G., and N. Salvadori. 2013. "The Construction of Long-Run Market Supply Curves: Some Notes on Sraffa's Critique of Partial Equilibrium Analysis." In *Sraffa's Legacy: Interpretations and Historical Perspectives*, edited by Enrico S. Levrero, A. Palumbo, and A. Stirati, 189–216. Vol. 3 of *Sraffa and the Reconstruction of Economic Theory*. Basingstoke: Palgrave Macmillan.
- Friedman, M. 1953. "The Methodology of Positive Economics." In *Essays in Positive Economics*, 3–43. Chicago: University of Chicago Press.
- Garegnani, P. 1990. "Comment." In *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, 283–301. London: Unwin Hyman.
- Garegnani, P. 2005. "On a Turning Point in Sraffa's Theoretical and Interpretative Position in the Late 1920s." *European Journal of the History of Economic Thought* 12, no. 3: 453–92.
- Kac, M. 1969. "Some Mathematical Models in Science." *Science* 166, no. 3906: 695–99.
- Kurz, H. D. 2020. "'Superhuman Efforts' and the Theory of Value and Distribution: Sraffa on Pareto." In *Conflict, Demand, and Economic Development: Essays in Honour of Amit Bhaduri*, edited by D. Basu and D. Das, 171–90. London: Routledge.
- Kurz, H. D. 2023. "On Physical Real Cost, Labour, and Metaphysics: Sraffa on Alternative Theories of Value and Distribution and on Pareto's Distinction between 'Literary' and 'Mathematical Economists.'" In *Classical Economics, Keynes, and Money*, edited by J. Eatwell, P. Commendatore, and N. Salvadori, 15–40. London: Routledge.
- Kurz, H. D., and N. Salvadori. 2005. "Representing the Production and Circulation of Commodities in Material Terms: On Sraffa's Objectivism." *Review of Political Economy* 17, no. 3: 413–41.
- Marshall, A. 1920. *Principles of Economics*. 8th ed. London: Macmillan.
- Mas-Colell, A., Michael D. Whinston, and Jerry R. Green. 1995. *Microeconomic Theory*. New York: Oxford University Press.
- McLure, M. 2007. *The Paretian School and Italian Fiscal Sociology*. Basingstoke: Palgrave Macmillan.
- Morishima, M. 1952. "On the Laws of Change of the Price System in an Economy Which Contains Complementary Commodities." *Osaka Economic Papers* 1:101–13.
- Moscatti, I. 2019. *Measuring Utility: From the Marginal Revolution to Behavioral Economics*. Oxford: Oxford University Press.
- Panico, C. 1991. "Some Notes on Marshallian Supply Functions." *Economic Journal* 101, no. 406: 557–69.

- Pigou, Arthur C. 1927. "The Laws of Diminishing and Increasing Cost." *Economic Journal* 37, no. 146: 188–97.
- Ricci, U. 1924. "Pareto e l'economia pura." *Giornale degli economisti e rivista di statistica* 65, no. 1–2: 27–44.
- Robinson, Joan V. 1941. "Rising Supply Price." *Economica* 8, no. 29: 1–8.
- Robinson, Joan V. 1951. Introduction to *Collected Economic Papers*. Vol. 1. Oxford: Blackwell.
- Salvadori, N. 2023. "Sraffa e Samuelson sugli equilibri parziali di Marshall: Conclusioni opposte da una stessa analisi?" *Atti della Accademia Nazionale dei Lincei*, forthcoming.
- Samuelson, Paul A. 1947. *Foundations of Economic Analysis*. Oxford: Oxford University Press.
- Samuelson, Paul A. 1967. *Economics: An Introductory Analysis*. 7th ed. New York: McGraw-Hill.
- Samuelson, Paul A. (1967) 2014. "The Monopolistic Competition Revolution." In *Paul Samuelson on the History of Economic Analysis: Selected Essays*, edited by Steven G. Medema and Anthony M. C. Waterman, 412–45. Cambridge: Cambridge University Press.
- Samuelson, Paul A. 1971. "An Exact Hume-Ricardo-Marshall Model of International Trade." *Journal of International Economics* 1, no. 1: 1–18.
- Samuelson, Paul A. 1987. "Sraffian Economics." In *The New Palgrave: A Dictionary of Economics*, edited by J. Eatwell, M. Milgate, and P. Newman, 4:452–61. London: Macmillan.
- Samuelson, Paul A. 1990a. "Reply." In *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, 317–30. London: Unwin Hyman.
- Samuelson, Paul A. 1990b. "Revisionist Findings on Sraffa." In *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, 263–301. London: Unwin Hyman.
- Samuelson, Paul A. 1991. "Sraffa's Other Leg." *Economic Journal* 101, no. 406: 570–74.
- Samuelson, Paul A. 2000. "Reactions to Kurz-Salvadori's Comments." In *Critical Essays on Piero Sraffa's Legacy in Economics*, edited by Heinz D. Kurz, 163–80. Cambridge: Cambridge University Press.
- Schefold, B. 1990. "Comment." In *Essays on Piero Sraffa: Critical Perspectives on the Revival of Classical Theory*, edited by Krishna Bharadwaj and Bertram Schefold, 301–17. London: Unwin Hyman.
- Signorino, R. 2000. "Method and Analysis in Piero Sraffa's 1925 Critique of Marshallian Economics." *European Journal of the History of Economic Thought* 7, no. 4: 569–94.
- Signorino, R. 2001. "An Appraisal of Piero Sraffa's 'The Laws of Returns under Competitive Conditions.'" *European Journal of the History of Economic Thought* 8, no. 2: 230–50.
- Sraffa, P. 1925. "Sulle relazioni fra costo e quantità prodotta." *Annali di economia* 2:277–328.

Sraffa, P. (1925) 1998. "On the Relations between Cost and Quantity Produced." Translated by John Eatwell and Alessandro Roncaglia. In *Italian Economic Papers*, edited by Luigi L. Pasinetti, 3:323–63. Bologna: Il Mulino; Oxford: Oxford University Press.

Sraffa, P. 1926. "The Laws of Returns under Competitive Conditions." *Economic Journal* 36, no. 144: 535–50.

Sraffa, P. 1930. "A Criticism [and Rejoinder]." *Economic Journal* 40, no. 157: 89–92, 93.

Sraffa, P. 1960. *Production of Commodities by Means of Commodities: Prelude to a Critique of Economic Theory*. Cambridge: Cambridge University Press.

Stigler, George J. 1950a. "The Development of Utility Theory." Pt. 1. *Journal of Political Economy* 58, no. 4: 307–27.

Stigler, George J. 1950b. "The Development of Utility Theory." Pt. 2. *Journal of Political Economy* 58, no. 5: 373–96.