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0. Introduction

In the mid-twelfth century, Gratian collected the wide range of 'discordant canons' coming from the various decisions of the Popes and Councils, thus giving birth, in the *Decretum,* to an apparently homogeneous body of doctrine known as the "Canon Law" – the law of the Church. Very much later, in 1973-1975, a short exchange appeared in *Economica* between Samuel Hollander and John Eatwell. This exchange concerned David Ricardo's early theory of profits, such as it emerged from his writings of the period 1813-1815, dominated by the publication of the *Essay on the Influence of a Low Price of Corn on the Profits of Stock* [1] in February 1815 – the same month when Thomas Malthus' *Inquiry into the Nature and Progress of Rent* and Edward West's *Essay on the Application of Capital to Land* were published. The articles by Hollander and Eatwell bear witness to the coexistence of two different 'canons' of Ricardian economics, to which Ricardo himself might have contributed in different ways. Now, unlike the medieval case, the Ricardian canons remained uncompromisingly conflicting. This paper precisely aims at explaining the intellectual process which led to such a coexistence.

The starting point of this process is Piero Sraffa's publication of the first volume of the edition of the *Works and Correspondence of David Ricardo.* This edition had matured for twenty years, and needed at this time twenty other years before being completed [2]. Sraffa's general introduction to this volume (Sraffa [1951]) renewed the admitted view on Ricardo's intellectual plan, and led to grant an utmost importance to the *Essay* [3] (**§ 1.1**). Reading this

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[1] Hereafter, *Essay on Profits*.

[2] About Sraffa's intellectual evolution between 1930, when H. Foxwell, President of the *Royal Economic Society*, entrusted him, on the suggestion of Keynes, the responsibility of the edition of the works of Ricardo, and the publication of *Production of Commodities* in 1960, see J.-P. Potier [1987] and L. Pasinetti [1990].

[3] This renewal should nonetheless be qualified. In a general context in which the interest for the *Essay* was in an inverse proportion of that for the *Principles*, two contributions emphasised the place of the 1815 text in Ricardo's work. The

last, Sraffa thought that it might be interpreted as a description of a two-sectors economy, agriculture and manufactures. The alleged particularity of agriculture was that corn is produced with corn, either directly as seed, or indirectly through the food provided to the cattle and to the workers (Sraffa [1951]: xxxi). On the contrary, in manufactures, goods are produced by means of themselves and of corn. A significant consequence results from this technological difference. From the point of view of the economy as a whole, the rate of profit appears as a ratio between the values of heterogeneous quantities – the physical surplus and the advanced capital. Henceforth, it depends on the relative prices of agricultural and manufactured products. Now – and this was the main analytical innovation involved in the Sraffian interpretation of the *Essay* – the particular case of agriculture, within the economy, deserves our attention: the physical homogeneity between agricultural product and means of production makes the agricultural profit rate independent of the structure of relative prices. Moreover, if one accepts the idea that competition between capitalists generates a uniform profit rate, it follows that this agricultural profit rate should also be the overall profit rate. The formal structure that Sraffa perceives in the *Essay* – the *corn-profit model* – hence makes it possible to view the identification of the profit rate as an operation logically prior to the identification of relative prices.

Ten years later, the same Piero Sraffa published *Production of Commodities by Means of Commodities* (**§ 1.2**). As it is well known, an interesting feature of this book is that it describes a "standard system", derived from the initial production system through a modification of the proportions of the different branches, so that its product and means of production might appear as different quantities of the same composite commodity (the "standard commodity" [4]). By expressing the wage rate in terms of this standard commodity, Sraffa thus succeeded in measuring the profit rate independently of the system of relative prices. The analogy with David Ricardo's *Essay* is striking, and the author did not deprive himself to evoke his classical inspirations: the standard system indeed appeared as a generalisation of agriculture in the corn-profit model, in which a composite commodity produced by means of itself would come to replace corn [5]. But Sraffa's 1960 contribution did not only make possible a formalisation of the Introduction of 1951. It also allowed to

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first one was H. Biaujeaud's PhD dissertation (Biaujeaud [1933]), which was praised by Sraffa himself (Sraffa [1951]: xxxviii n.) for its "unusual view" on the evolution of Ricardo's theory of value, but which did not actually interpreted the *Essay* as a corn-profit model. Anyway, Biaujeaud's work was to remain confidential. However, the second contribution might have had a far greater influence: W. Mitchell's lectures were published two years before Sraffa's Introduction, and clearly expressed – up to our knowledge, for the first time – that the discussion of agriculture in the *Essay* was based on the idea that capital and output were the same commodity (W. Mitchell [1949]: 141).

[4] The procedure of construction of the standard system and of the standard commodity, in the elementary case of simple production with surplus, is presented by Sraffa in chapters 4 and 5 of his book.

[5] See Sraffa [1960]: Appendix D.

reconsider the constitution of the canon of Ricardian economics (**§ 1.3**). Under this respect, the *Principles* appeared as a detour from the direct route leading from Ricardo's *Essay* straight to Sraffa's *Production of Commodities*.

The following thirteen years were punctuated by P. Sraffa's edition of the eleven volumes of Ricardo's works and correspondence. Simultaneously, *Production of Commodities* was to play a central part in the development of what has been known as the "Cambridge controversies" [6]. Thirteen years: resting both on historical (the Introduction of 1951) and on analytical (*Production of Commodities*) grounds, the Sraffian influence was presumably at its culminating point. It was in this context that Samuel Hollander published an article challenging Sraffa's interpretation of the *Essay* (Hollander [1973]). Drawing on the *Essay* itself, as well as on Ricardo's correspondence, S. Hollander didn't find any textual evidence favouring the assumption of physical homogeneity between product and means of production in agriculture (Hollander [1973]: 265-7). Nevertheless, this last was not completely dismissed from Hollander's understanding of Ricardo's plan, but rather reconsidered as a highly disputable rhetoric argument, leaving room to the repeated idea that the rate of profit is determined by the money wage rate (**§ 2.1**).

The controversy which followed, between Eatwell and Hollander (Eatwell [1975], Hollander [1975]), made obvious that these conflicting interpretations of Ricardo's *Essay on Profits* rested on methodological and analytical divergences (**§ 2.2**). Whereas the Sraffa-Eatwell interpretation aimed at a rational reconstruction favouring comparative statics, the Hollander interpretation tended to an historical reconstruction, giving the first place to dynamics. The consequences of such a divergence are analysed through Eatwell's opposition to Hollander's assertion that, according to Ricardo, an increase in the price of corn answered to a decrease in agricultural productivity, in order to prevent the profit rate from falling – this latter diminishing afterwards, as a result of the increase in the money wage rate (**§ 2.3**). In the context of a simple linear model assuming input-output physical homogeneity in agriculture, it is then shown that even if the rate of profit can be determined independently of prices from a comparative statics point of view (Eatwell's position), this is no more true within a dynamic framework, since the variations of the money wages and prices explain the process of adjustment (Hollander's position).

The consequence is obvious. A solvable debate between the two interpretations of the *Essay* would require a sufficient intersection between the protagonists' analytical and methodological positions. Such was not – and is still not – the case. As far as the

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[6] According to the title of G. Harcourt's book in 1972: *Some Cambridge Controversies in the Theory of Capital.*

interpretations of the *Essay* concerned two conflicting legitimacies – we mean: two legitimate analytical and methodological approaches – which cannot be indisputably settled, the controversy became, from a scientific point of view, a non-debate (**§ 3**). Both interpretations are thus condemned to coexist in an endless conflict: the Ricardian canons remain irreconcilable.

1. The Neo-Ricardian Foundations of Ricardian Economics

1.1. Ricardo, over Sraffa's shoulder: the "Introduction" of 1951

Still today, in spite of the distance which separates us from the publication of the first volumes of Ricardo's *Works*, in spite of the emergence of the theory of prices of production within contemporary economic knowledge, the thesis of the "Introduction" of 1951 remains brilliant. The pages devoted to the *Essay* favour a comparative statics perspective rather than an approach in terms of dynamics. Now, when following this comparative statics approach, Sraffa shows himself more a palaeontologist than an historian: from Ricardo's *writings*, such as we know them, he draws carefully a Ricardian *theory*, such as it might have been. The most significant trace of this theory would be the well-known Table of the *Essay*, "which shows the effects of an increase of capital, both capital and the 'neat product' are expressed in corn, *and thus the profit per cent is calculated without need to mention price*" (Sraffa [1951]: xxxii; our italics, A.L.-N.S.). In particular, the second part of the Table, which recapitulates the results established in the first, shows the existence of an inverse relation between profit and rent, without the knowledge of prices being apparently required.

Still like the palaeontologist who infers general morphological regularities from anatomical particularities, Sraffa ([1951]: xxxi) does not provide any definite textual evidence that, according to Ricardo, the "rational foundation of the principle of the determining role of the profits of agriculture […] is that in agriculture the same commodity, namely corn, forms both the capital […] and the product; so that […] the determination of the ratio of this profit to the capital, is done directly between quantities of corn without any question of valuation". Of course, this may lead one to look for more convincing anatomical particularities in Ricardo's works. But, on the other hand, it raises the question of knowing why it was so necessary, one century and a half after the writing of the *Essay*, to disclose in Ricardo's writings some explicit statement of this "rational foundation". Obviously, if Sraffa's intention was only to determine a rational foundation, the compatibility of this statement with the propositions which it relates to would have been conclusive, even against Ricardo's explicit aim. So that there is no clear necessity to the rational foundation an historical foundation.

Assuming that this rational foundation also takes place within the works of Ricardo – i.e., is also an historical foundation – would hence only strengthen the Sraffian interpretation of the *Essay*: what Ricardo did would appear more convincingly as the result of our rational reconstruction if we can establish that it is also a faithful description of what Ricardo intended to do. The search for an historical foundation of the Sraffian interpretation thus appears as the search for a lateral argument, which would seriously neither confirm, nor invalidate, the main thesis.

It is outside the *Essay* [7] that Sraffa extends his investigation, in order to find such an historical foundation. Two elements are selected from Ricardo's correspondence. The first consists of an extract from a letter to Malthus, dated June 26 1814, in which Ricardo explains that "[t]he rate of profits and of interest must depend on the proportion of production to the consumption necessary to such production" (*Works*, VI: 108). The second element is only an indirect index since it concerns a letter sent to Ricardo by Malthus on August 5 1814, in which the latter refutes the idea of a rate of return expressed in physical terms [8]. Following Sraffa, this would suggest that Ricardo had indeed supported the rejected thesis – either in lost "papers on the profits of Capital", or on the occasion of a private conversation.

Of course, such a material is a little bit too flimsy to persuade a sceptical reader. From this point of view, the rational reconstruction of what the Ricardian theory might have been – independently of what Ricardo actually said – is far more convincing. Not only is the assumption that in agriculture the means of production and the product consist of the same commodity a consistent explanation of the leading role of agricultural profits, but it also makes consistent Ricardo's intellectual itinerary, from the *Essay* up to the successive editions of the *Principles* as from 1817, and to "Absolute Value and Exchange Value", written just before his death in 1823. Still according to Sraffa – who inserted his interpretation of the *Essay* in the section of his "Introduction" devoted to the chapter on value of the first edition of the *Principles* – Ricardo worked his analysis of value during the period of gestation of his major work, "out of the fragmentary elements of such a theory which are to be found in the *Essay*" (Sraffa [1951]: xxx). As from the 1817 edition, indeed, Ricardo would have developed a theory of value allowing him to give up the "considerable simplification" of the *Essay* –

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[7] Other textual arguments, supporting Sraffa's interpretation, were to be added progressively. For example, the footnote in the *Essay* (*Works*, IV: 12), where Ricardo specifies his plan, explaining that he was only "desirous of proving that the profits on agricultural capital cannot materially vary, without occasioning a similar variation in the profits on capital, employed on manufactures and commerce", came into the debate (see, for instance, S. Hollander [1973] : 275, who nonetheless rejects Sraffa's interpretation).

[8] See Sraffa ([1951]: xxxi-xxxii), who quotes Malthus' objection according to which "[i]n no case of production, is the produce exactly of the same nature as the capital advanced. Consequently, we can never properly refer to a material rate of produce" (*Works*, VI: 117).

corn produced exclusively with corn – so that the agricultural rate of profit would have been deprived of its determining role in the economy. As attested by the successive transformations of the chapter "On Value" of the *Principles*, the operation was not so simple. But the new theory of value would have made it possible, for Ricardo, to conceive a derived form of homogeneity between capital and product, "the rate of profits [being determined] by the ratio of the total labour of the country to the labour required to produce the necessaries for that labour" (*Ibid.*: xxxii).

From the *Essay* to the *Principles*, Ricardo's objective would then have remained the same: as stated in the "Preface" of this last work, the "principal problem in Political Economy" was of determining the laws which regulate distribution (*Works*, I: 5). Under this respect, the issue of value – accessory in the *Essay*, essential in the *Principles* – is subordinated to that of distribution: as Sraffa states it, "the problem of value which interested Ricardo was how to find a measure of value which would be invariant to changes in the division of the product" (Sraffa [1951]: xlviii). The question was raised, but it remained open. At least until 1960, when Sraffa provided it with its missing answer.

1.2. *Production of Commodities*: a Child's Guide

The publication, in 1960, of *Production of Commodities* made it clear that the stake of the Sraffian interpretation of the *Essay* did concern the whole Ricardian system. Whereas the effect of the Introduction, in 1951, was to contrast a preliminary – simplified, but consistent – version of the Ricardian economics to a more general but unfinished version – in the *Principles* – the 1960 book revealed that the simplification of the preliminary version might be given up without any counterpart, so that this early work was a carrier, in an embryonic form, of what the general version did not succeed to achieve.

Before the appearance of *Production of Commodities*, the permanency of a Ricardian tradition primarily expressed in the framework of models of accumulation and distribution, sometimes with one single agricultural sector (N. Kaldor [1955-6]), sometimes with two or more sectors (corn and gold, respectively necessary and luxury goods in L. Pasinetti [1959-60]), in which i) labour was the only factor of production, ii) wages – made up with corn – constituted the only advance of capital, and iii) decreasing returns prevailed in agriculture and constant returns in other activities. Such contributions already emphasised the place of surplus in neo-Ricardian economics, and highlighted the main features of the dynamics of capitalism described by Ricardo: increase of rent and decrease of the profit rate, independence of distribution *vis-à-vis* relative values, determining role of necessary goods. P. Garegnani's book ([1960]), drawn from his PhD dissertation, systematised the critical dimension of an

economic reflection based on a classical thought reconstructed by means of Sraffa's 1951 Introduction [9]. However, before the publication of *Production of Commodities*, it was probably impossible to anticipate that the theory of prices of production developed in this last book would allow neo-Ricardian economics to enjoy such an expansion, so that it could pretend to inherit the Ricardian legacy.

The theory of prices of production, in the elementary case of "simple production with surplus" presented by Sraffa in his 1960 book, has now become quite familiar. The price system $\mathbf{p} = [p_i] \geq 0$ ($i = 1,... n$), the wage rate w and the profit rate r are solutions of the equation [10]:

$$(1+r)\mathbf{Ap} + \mathbf{l}w = \mathbf{p} \qquad [1]$$

where $\mathbf{A} = [a_{ij}] \geq 0$ ($i, j = 1,...n$) is the matrix of production in which a_{ij} represents the quantity of commodity j required as mean of production of one unit of commodity i [11], and where $\mathbf{l} = [l_i] > 0$ ($i = 1,...n$) is the vector of direct labour used in the production of each commodity i. It should be noted that wages, like profits, are withdrawn from the net product, and not advanced at the beginning of the period. The unit of account for prices and wages is derived from the construction of the "standard system" – this latter being simply a linear transformation of the initial production system, obtained by applying to each branch i a coefficient $q_i \geq 0$, so that:

$$\mathbf{qA} = \lambda \, \mathbf{q} \qquad \text{(where } \mathbf{q} \text{ is normalised by } \mathbf{ql} = 1\text{).}$$

$\lambda \geq 0$ and $\mathbf{q} = [q_i] \geq 0$ are respectively the dominant eigen-value of the matrix $\mathbf{A}$ and its associated left-hand eigen-vector. As a result, $\mathbf{qA}$ and $\mathbf{q}$ might be interpreted like the means of production and the product, physically homogeneous, of a composite "standard commodity". The prices and the rate of wages are then normalised on the basis of the net product of the standard system, i.e.:

$$\mathbf{q}(\mathbf{I} - \mathbf{A})\mathbf{p} = 1.$$

Denoting $R = (1/\lambda) - 1$ the physical rate of return of the standard system, the rate of profit which, in equation [1], seemed to depend on relative prices, now appears as independent of the price system, in what is known as "Sraffa's relation":

$$r = R(1-w) \qquad [2].$$

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[9] The hypothesis of a physical homogeneity in agriculture in the context of the *Essay* is hence considered as granted by Garegnani, and it plays the same role as for Sraffa to understand Ricardo's evolution from the *Essay* to the *Principles*. (Garegnani [1960]: 20-3).

[10] One is indebted to P. Newman [1962] for the first formalisation of Sraffa's 'simple production with surplus', using notations and results from the methodology of linear models.

[11] In accordance with Sraffa's own interpretation ([1960] : v), it is not necessary to assume constant returns: it is indeed sufficient to normalise quantities a_{ij} on the basis of the total production of each branch i.

The procedure used to construct the standard system shows an interesting property. If $\mathbf{A}$ is irreducible, cannot be re-written $\mathbf{A} = \begin{bmatrix} \mathbf{A_{11}} & \mathbf{0} \\ \mathbf{A_{21}} & \mathbf{A_{22}} \end{bmatrix}$ ($\mathbf{A_{11}}$ being itself an irreducible square matrix), $\mathbf{q}$ is strictly positive, which implies that each commodity enters in the composition of the standard commodity. On the contrary, if $\mathbf{A}$ is reducible and $\lambda(\mathbf{A_{11}}) > \lambda(\mathbf{A_{22}})$ [12], $\mathbf{q} = [\mathbf{q_1}, \mathbf{q_2}]$ is such as $\mathbf{q_1} > \mathbf{0}$ and $\mathbf{q_2} = \mathbf{0}$. Therefore, "basic commodities" only – i.e. commodities which are both products and means of production in the sub-system $\mathbf{A_{11}}$ – are parts of the standard commodity, all other ("non-basic") commodities being excluded [13].

1.3. A neo-Ricardian interpretation of Ricardo's writings

Without referring explicitly to the *Essay*, Sraffa however pointed out, in Appendix D to *Production of Commodities*, the similarity between his own approach and the one that he ascribed to Ricardo. Henceforth, the same elementary formalisation makes it possible to represent simply the thesis of the *Essay*, such as it is understood by Sraffa. But there is a second step in this process of extension of the formalisation of *Production of Commodities*, where the *Principles* are also concerned. Not in the same way as the *Essay*: if the reader is persuaded that the corn-profit model did constitute the analytical core of the *Essay*, he is also persuaded that, for want of mathematical skill, Ricardo missed the point in the *Principles*. From 1960 onwards, it became evident that remaining faithful to the *question* raised by Ricardo required that one stood aloof from the kind of *answer* provided in the successive editions of the *Principles*. Indeed, the Sraffian theory of prices of production showed that the assumption of the *Essay* on homogeneity in agriculture was not as drastic as it seemed to be: this assumption could be given up without implying the tedious working-out of the different versions of the first chapter on value, in the *Principles*; without preventing the profit rate from remaining a ratio of homogeneous quantities, independent of the price system [14].

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[12] This assumption allows to cancel out the 'freak case' imagined by Sraffa ([1960]: 90-91), in which the rate of reproduction of a non-basic good used in its own reproduction is so low as to be lower than that of the standard system.

[13] This introduction of Sraffa's model of simple production remains quite elementary. For a more thorough discussion of the formal properties of the model, see for instance, among many other references, L. Pasinetti [1975]: 77-121, G. Abraham-Frois and E. Berrebi [1976], C. Bidard [1991], H. Kurz et N. Salvadori [1995]: 94-118.

[14] A similar position, following Sraffa's own remarks ([1960]: Appendix D) was supported by various commentators in the years which followed the publication of *Production of Commodities*. See, for example, C. Napoleoni [1961], J. Robinson [1961] or L. Meldolesi [1966].

1.3.1. The corn-profit model as a model

The corn-profit model has now become some kind of common knowledge. It might be represented as follows [15].

Assume that the productive combination of branch $i = 1$ is that of the land which pays no rent, that prices are expressed in terms of corn ($p_1 = 1$), and that w now denotes a rate of real wage, exclusively made up with corn. In order to elude the problems raised by the coexistence of fixed and circulating capital in the Ricardian system, it is also assumed that wages are part of the circulating capital – advanced at the beginning of the period – and that there is no fixed capital properly speaking. Natural prices $\mathbf{p}$ hence appear as solutions of:

$$(1+r)(\mathbf{Ap}+\mathbf{l}w)=\mathbf{p}$$

or, writing $\mathbf{A}^*(w)$ the matrix the elements of which are $a_{i1}^* = a_{i1} + l_i w$, and $a_{ij}^* = a_{ij}$ for all $j \neq 1$:

$$(1+r)\mathbf{A}^*(w)\mathbf{p} = \mathbf{p} \qquad\qquad [1a].$$

At first glance, just like in the ordinary model of prices of production, the determination of the profit rate r does not seem independent from that of the natural prices $\mathbf{p}$. Nonetheless, the Sraffian hypothesis of homogeneity in agriculture being expressed by $a_{11} > 0$ and $a_{1j} = 0$ for all $j \neq 1$, corn appears as the only basic commodity in the sense defined above. It follows that the rate of profit r is determined in agriculture only (the standard system, reduced to a single-commodity economy), without any reference to other prices:

$$r = \frac{1-(a_{11}+l_1 w)}{a_{11}+l_1 w} \qquad\qquad [2a].$$

The fundamental principle that Sraffa believed he had found in Ricardo's *Essay* hence finds an analytical expression [16]. Obviously, the weight of this analytical expression should not be overestimated: it only bears witness to the consistency of Sraffa's intuition as from 1951. But the advantage of this quite elementary formalisation is that it helps focussing on the fact that further orientation of the Ricardian system, such as perceived by Sraffa, is related to i) the permanent will to establish the logical priority of distribution on prices; ii) the relaxation of the assumption of physical homogeneity in agriculture.

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[15] See the references *supra* note 13. This presentation deliberately leaves aside the way historical and analytical investigations were related in the course of Sraffa's career; on this question, see A. Lapidus [1996] : 883-9.

[16] This expression goes, however, beyond Ricardo explicit intention, since the variations of r generated by the variations of w usually come with an adjustment of the prices of non-basic goods, whereas in the *Essay*, Ricardo changed his previous opinion and assumed that industrial prices remain constant when their conditions of production do not vary (see Sraffa [1951]: xxxiv).

1.3.2. What could have been found in the *Principles*, had Ricardo been Sraffian

It should be clear for the modern reader that this double requirement, even in the more complex context of the *Principles*, did not necessitate all the subtleties of the chapter on value. Rewriting the *Principles* in the light of *Production of Commodities* is therefore a much different exercise from that of rewriting the *Essay*. The outcome is not an alleged analytical core of the *Principles*, but a consequence of the analytical core of the *Essay*.

The only differences introduced by the generalisation of the corn-profit model to the *Principles* is that the physical wage rate, instead of being made up exclusively with corn, from now on appears as a basket of goods $\mathbf{w} = [w_i]$ ($i = 1,...\ n$) and that the elements a_{1j} of matrix $\mathbf{A}$ are no more necessarily equal to zero when $j \neq 1$. The matrix $\mathbf{A}^*(\mathbf{w})$ in equation [1a] is thus redefined as $a_{ij}^* = a_{ij} + l_i w_j$ ($i,j = 1,...\ n$). And the system of natural prices can be written as follows:

$$(1+r)\mathbf{A}^*(\mathbf{w})\mathbf{p} = \mathbf{p} \qquad\qquad \text{[1b]}.$$

The same procedure as that used in the construction of the standard system can thus be employed. If, like previously, $\mathbf{q}$ represents the left-hand eigen-vector of $\mathbf{A}^*(\mathbf{w})$, associated to its dominant eigen-value λ, it is observed that :

$$r\,\mathbf{q}\mathbf{A}^*(\mathbf{w}) = \mathbf{q}(\mathbf{I} - \mathbf{A}^*(\mathbf{w})) \qquad\qquad \text{[2b]}.$$

So that, even within the general framework of the *Principles*, the rate of profit may appear as a ratio, independent of the price system, between homogeneous quantities. Here again, the distinction between basic and non-basic commodities – which echoes the Ricardian distinction between necessary and luxury goods – makes it clear that only basic commodities enter the construction of the standard system and, like corn in the model of the *Essay*, in the quantitative ratio from which the profit rate is derived.

The analogy between the formal structures of equations [1]-[2], [1a]-[2a], and [1b]-[2b] highlights the new dimension of the stake of the Sraffian interpretation of the *Essay*, after the publication of *Production of Commodities*. For the reader who agreed with Sraffa's interpretation ten years ago, the *Essay* displayed a correct but oversimplified theory, whereas the *Principles* were general enough, but somewhat confusing. Now, from 1960 onwards, the *Principles* clearly appeared as misleading. Equations [1b]-[2b] should now represent the solution – technically out of reach to David Ricardo at the time he was writing the *Principles* – to the obstacles raised by the relaxation of the *Essay* hypothesis of physical homogeneity in agriculture. Therefore, [1b]-[2b] would now occupy an intermediary position, between the pioneering construction of the *Essay* given by equations [1a]-[2a], and the modern formulation of a theory of prices of production in equations [1]-[2]. The joined effect of

Sraffa's 1951 and 1960 contributions is hence to revise the place usually granted to Ricardo in the history of economics: a – presumably major – contributor to Ricardian economics.

2. From Palaeontology to Speleology: Hollander's Challenge, 1973-1975

One had to wait the 1970's to attend an actual challenge of the Sraffian interpretation of the *Essay*. This occurred through an article of Sam Hollander published in *Economica* (Hollander [1973]), followed by a short controversy with John Eatwell in the same journal (Eatwell [1975]; Hollander [1975]).

2.1. Ricardo, over Hollander's Shoulder : Strong and Weak Propositions in the *Essay on Profits*

The originality of Hollander's historiographic approach was to identify in Ricardo's writings a strategy of argumentation which develops throughout the period 1813-1815. The principle of this strategy leads one to distinguish between:

i) the "essence of the *Essay*" (Hollander [1973]: 282) – unfortunately referred to by the phrase 'weak proposition' (*Ibid*.: 275) –, which constitutes the core of Ricardo's message, according to which the general profit rate is determined by the money wage rate, itself influenced (non-exclusively) by the price of corn, which depends on the productivity in agriculture;

ii) the over-simplified argument which at least makes the discussion easier – the 'strong proposition', as Hollander (*Ibid*.: 269-270) calls it –, synthesised in the well-known statement that the overall profit rate is regulated by the agricultural profit rate [17].

Hollander detects the presence of the weak proposition in Ricardo's correspondence with Malthus as from the middle of 1813. His numerous references to the determinant role of agriculture express the fact that, via the price of subsistence goods, the fall in agricultural productivity is reflected in the wage level and consequently affects the general profit rate. The very same materials which were the main basis for Sraffa's interpretation are thereby called upon to support quite a different theory.

On rereading Ricardo's letter of 26 June 1814 to Malthus in which he explained the profit rate by the "proportion of production to the consumption necessary to such production" (*Works*, VI: 108) and where Sraffa identified two physically homogeneous magnitudes, Samuel Hollander ([1973]: 262) finds textual evidence that, according to Ricardo, this ratio "depends upon the cheapness of provisions, which is after all [...] the great regulator of the wages of labour" (*Works*, VI: 108).

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[17] Typically, this position is expressed in Ricardo's letter to H. Trower of 8 March 1814: "it is the profits of the farmer which regulate the profits of all other trades" (*Works*, VI: 104).

In the same way, Hollander ([1973]: 265-6) sees in Malthus' objection when corresponding with Ricardo that "[i]n no case of production, is the produce exactly of the same nature as the capital advanced" (Letter of August 5 1814, *Works,* VI:117) not the echo of any past conversation or of lost notes, but very probably of a letter written by Ricardo several days beforehand in which he wrote that "[t]he capitalist 'who may find it necessary to employ a hundred days labour instead of fifty in order to produce a certain quantity of corn' cannot retain the same share for himself unless the labourers who are employed for a hundred days will be satisfied with the same quantity of corn for their subsistence that the labourers employed for fifty had before" (Letter to Malthus of July 25 1814, *Works*, VI: 114-5). At first glance, this extract appears to confirm Sraffa's interpretation. But Hollander mentions two letters written in the same period, which contextualise the previous one [18] and reflect the permanent position of Ricardo – the weak proposition favouring the effect of variations in money wages on profits – a position which was to strengthen despite the circumstantial wording adopted in his letter of July 25.

Therefore, not only should the text of the *Essay* be re-appraised in the light of its author's correspondence, but it is, in Hollander's opinion, far from providing the textual arguments that Sraffa believed he would discover within it. The Table, which was its centrepiece, in no way illustrated a reasoning within which the product and the means of production would be physically homogeneous. Ricardo no doubt introduced a capital *estimated* in corn; but in no way was this a capital *composed* of corn (Hollander [1973] : 274) [19]. In such a manner that the latter is no more than a unit of account, which is confirmed by Ricardo's own commentaries on the Table, neglected by the Sraffian interpretation. It thus becomes easier to understand Ricardo's already quoted assertion in the *Essay*, stating that he only aimed at "proving that the profits on agricultural capital cannot materially vary, without occasioning a similar variation in the profits on capital, employed on manufactures and commerce" (*Works*, IV: 12 n.), not as an argument in favour of the strong proposition, but as the expression of the impossibility of agricultural and industrial profit rates diverging in the long run (Hollander [1973]: 275-6). It thus appears, according to Hollander's interpretation, that whereas the weak proposition – rooted in the 1813-1814 correspondence – would imply the theoretical results of the *Essay*, Ricardo happened to reinforce it rhetorically by an ambiguous use of the strong proposition – the determining role of the agricultural profit rate – this last ultimately referring to the somewhat different assertion that competition equalises the profit rates.

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[18] Letters of June 26 and August 11 1814; *Works*, VI: 108 and 119-20.

[19] Hollander ([1973]: 274 n.) mentions, for example, the title of the first column of the Table in the *Essay*: "Capital estimated in quarters of corn" (*Works*, IV: 17).

2.2. Historiographical Divergence, Analytical Divergence

Despite the apparent strength of the textual counter-arguments, the appreciation Hollander produced of Sraffa's interpretation of the *Essay* remained surprisingly qualified. Indeed, his aim was not to confirm that the hypothesis of a corn-profit model – the strong proposition – is lacking in Ricardo's presentation, but rather to discuss its place within it. In the same way, he seems to have no serious quarrel with the importance, *today*, of a determination of the profit rate independently of prices in the theory of prices of production. Symmetrically, the position defended by Sraffa in the Introduction of 1951 obviously leads to the conclusion that variations in wage rate and variations in the overall profit rate are opposite. At the outset, the divergence is thus seen to be historiographic: whereas Sraffa attempts to reconstruct some sort of *objectivity* regarding Ricardo's message – an objectivity which may emerge without Ricardo himself being aware of it – Hollander endeavours to reveal a Ricardian *rhetoric* – a strategy of argumentation which appears in the absence of conclusive demonstrative elements. Now, this objectivity does not become more apparent by means of explicit words – except to consider as equivalent what Ricardo said, what he meant and what the theorist understands by it today – than rhetoric is given for what it is – except to compromise what enables its existence : the private information of the author concerning the distance between what he says and what he means. Sraffa's palaeontology, which reconstructs what may have existed, finds a counterpart in Hollander's speleology seeking what was intended to remain hidden. In a symptomatic manner, Sraffa speaks of "rational foundation" ([1951]: xxxi), Eatwell talks of a "presumably indisputable" formal basis ([1975]: 185), whereas Hollander seeks to find what Ricardo had – or did not have – "in mind" ([1973]: 281; [1975]: 190). With an ingenuity which was, perhaps, real, Hollander acknowledged the irreducibilty of these two approaches in his reply to Eatwell's reaction to his article: "my interpretation in no way touches upon the 'usefulness' of the corn profit model as an analytical structure. It is the historical question of whether we can legitimately attribute such a structure to Ricardo which is the subject matter of my article" (Hollander [1975]: 201). This observation does not put a definite end to the debate however, by opposing its protagonists: it is simply an incentive to remind us that methodological divergences can give rise, on the one hand, to an agreement on wider conclusions; but, on the other hand, to much narrower possibilities for debate than those which were initially imagined.

However, these possibilities for debate between Sraffa's interpretation and that of Hollander are still reduced, drastically, as the change in the historiographical perspective is coupled with a change in analytical perspective. As already noticed, the pages Sraffa devotes

to the theory of profit in the *Essay* come under comparative statics. Now, from this point of view, the leading effect of the agricultural profit rate laid down by the strong proposition reflects not a temporal causality expressed via an adjustment mechanism, but a structural independence of agriculture compared to the structural dependence of industry. In the same way, the weak proposition still within the Sraffian context, would suggest that the effect of money wages on the profit rate should only be seen via the succession of states of equilibrium which goes hand in hand with the cultivation of less and less fertile land. On the contrary, Hollander's article aims at highlighting the interactions between adjustment dynamics, outlined by Ricardo in the *Essay* and in his correspondence during the period 1813 to 1815. Although this perspective does not discredit the meaning, from a Sraffian point of view, of the strong and weak propositions, it does encourage a different interpretation of them to be favoured. Thus, the strong proposition, understood this time as being in a dynamic perspective, not only supposes the structural independence of agriculture as in the case of comparative statics; but it also signifies that i) the mechanisms determining the rate of agricultural profit have no direct action upon the industrial profit rate; ii) the variation in the agricultural profit rate generates an adjustment mechanism of the industrial profit rate, at the end of which the second had come into line with the first. At the same time, the weak proposition means that i) the factors influencing the money wage rate have no direct influence on the general profit rate; and ii) the variations in money wages give rise to an adjustment in both the agricultural and industrial profit rates.

2.3. The non-debate issue

2.3.1. Hollander, over Eatwell's shoulder

John Eatwell's answer [1975] to Samuel Hollander perfectly illustrates this quasi-suppression of the possibilities of debate, originating from this double change in perspective. For want of a sufficiently wide intersection between the respective contributions of Sraffa and Hollander, Eatwell seems reduced to merely recalling Sraffa's argumentation. On the one hand he insists upon the specificity of Sraffa's historical approach, by underlining with some acrimony that "[e]vidently, Hollander has not understood the logic of the role which the standard of value plays in Ricardo's theory of distribution, and the puzzle that Ricardo was trying to solve in the *Essay on Profits*" (Eatwell [1975]: 183). It is quite natural that here, the "puzzle" is the one Sraffa lends Ricardo, and that in his attempt to solve it, although the deliberate will of the author of the *Essay* is mentioned, it remains of secondary importance. And when this will is unambiguously expressed, for both Eatwell and Sraffa, it is to break, in the *Principles*, with the problematic of the *Essay* by introducing a value theory, perhaps sketched out, but assuredly superfluous in the text of 1815. It is thus understandable that in

his reply to Eatwell, Hollander ([1975]: 188) – for whom the permanence of the weak proposition and the need for an outline of a theory of value in 1815, reflect the continuity of the Ricardian plan from the *Essay* to the *Principles* – sees his opponent's position as "based upon a preconceived notion of the nature and content of Ricardian profit theory and of Ricardo's place in the history of economic thought": the "preconceived notion", from the point of view of an author careful to underline a strategy of argumentation in Ricardo's work, is hardly an affable way to highlight the attempt at the rational reconstruction of an objectivity which is not apparent at first glance.

On the other hand, the evaluation given by Eatwell regarding Hollander's contribution is even harsher, given that, placed within the Sraffian context of comparative statics, he agrees there is "*no* incompatibility" (Eatwell [1975]: 182) between the decisive role of money wages on profits (the weak proposition) and the argument of Sraffa (strong proposition). A remarkable sign of the narrowness of the intersection between the interpretations of the *Essay* in terms of comparative statics and of dynamics is to be seen through the brief exchange concerning the equalisation of profit rates. S. Hollander ([1973]: 276-7) highlighted an error in the reasoning of Ricardo – an error that other passages from the *Essay* managed to correct – when he imputed the fall in the agricultural profit rate to the decrease in productivity in this sector, and the fall in industrial profit to the increase in money wages. Quite the contrary, explains Hollander, the "increase in the price of corn reflects the fall in agricultural productivity and *to this extent* any fall in agricultural profits is *prevented*. Profits decline in agriculture for precisely the same reason that they decline in manufacturing, namely as a consequence of rising money wages" (*Ibid*.: 277). Eatwell's reply, in a simple footnote, seemed unanswerable: "this is nonsensical in the case of the Table in the *Essay* in which input and output are the same commodity, and hence no change in price can alter the rate of profit in agriculture" (Eatwell [1975]: 185 n.).

Obviously, Eatwell's assertion is supported by the consequences, from the point of view of comparative statics, of the hypothesis of physical homogeneity in agriculture. In a more formal manner and to simplify the presentation, it will be supposed, using the notations of § 1.3, that the economy is divided into two sectors: agriculture producing corn, and factories producing gold. Let p_1 and s be the money price of corn and the money wage rate – i.e. expressed in gold, whose conditions of production do not vary. The technologies on the marginal land at dates t_0 and t_1 are respectively $\left(a_{11}^0, l_1^0\right)$ and $\left(a_{11}^1, l_1^1\right)$, so that $a_{11}^0 \leq a_{11}^1$ and $l_1^0 < l_1^1$ – which expresses the fall in agricultural productivity between these two dates. Initially, the profit rate r^0, prices p^0 and the monetary wage rate s^0 are such that:

$$\left(a_{11}^0 p_1^0 + l_1^0 s^0\right)\left(1 + r^0\right) = p_1^0 \qquad \text{[3a]}$$

$$\left(a_{21} p_1^0 + l_2 s^0\right)\left(1 + r^0\right) = 1 \qquad \text{[3b]}$$

$$s^0 = wp_1^0 \qquad\qquad\qquad\qquad [3c].$$

When agricultural productivity has fallen, the same profit rate, price and wage rate, r^1, p^1 and s^1 are the solutions to:

$$\left(a_{11}^1 p_1^1 + l_1^1 s^1\right)\left(1+r^1\right) = p_1^1 \qquad\qquad [4a]$$

$$\left(a_{21}^1 p_1^1 + l_2 s^1\right)\left(1+r^1\right) = 1 \qquad\qquad [4b]$$

$$s^1 = wp_1^1 \qquad\qquad\qquad\qquad [4c].$$

The equations [3a]-[3c] and [4a]-[4c] evidently confirm Eatwell's point concerning the absence of any effect of the variation in the price of corn on the agricultural profit rate, since r^0 and r^1 can be calculated independently from price. It is also to be noted that the real wage rate being given, prices are determined by the relative production conditions of corn and gold. Eatwell's concession to Hollander is thus founded, as the increase in the price of corn ($p_1^1 > p_0^0$) goes hand in hand with an increase in money wages ($s^1 > s^0$) and with a fall in the profit rate ($r^1 < r^0$).

2.3.2. Hollander's mechanism

Despite this, Hollander's argument was of a different nature. Its implications, even in the apparently most unfavourable case, when the hypothesis of structural independence of agriculture has been accepted (the strong proposition from the point of view of comparative statics), is not without interest. Let us keep the point of departure given by the equations [3a], [3b] and [3c]. As with Eatwell, profit rates are determined independently of price. However, the adjustment suggested by Hollander supposes that the effects of the shock formed by the fall in agricultural productivity are not *immediately* shown by equation [4a], but by an increase in the price of corn from p_1^0 to $\tilde{p}_1^0$ which would keep the profit rate at the same level $\tilde{r}^0$ in both agriculture and industry [20], whereas money wages would remain constant:

$$\left(a_{11}^1 \tilde{p}_1^0 + l_1^1 s^0\right)\left(1+\tilde{r}^0\right) = \tilde{p}_1^0 \qquad\qquad [5a]$$

$$\left(a_{21} \tilde{p}_1^0 + l_2 s^0\right)\left(1+\tilde{r}^0\right) = 1 \qquad\qquad [5b].$$

The resulting fall in the real wage rate should thus give rise to a dynamic adjustment in the money wage rate, which Hollander noticed in Ricardo's writings as from the correspondence with Malthus in the years 1813-1814, concerning the effects of a restriction of corn imports (Hollander [1973]: 260-5). This adjustment could take the form:

$$\dot{s}^t = k\left(w\tilde{p}_1^t - s^t\right) \qquad (k>0) \qquad\qquad [6],$$

where w is the real wage rate in corn at t_0, now different from the real wage rate at t, $c^t = \dfrac{s^t}{\tilde{p}_1^t}$.

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[20] Hollander seems to have admitted that the profit rate remains unchanged at r^0. But this can only be so either in the – after all, not so – particular case where $a_{21} = 0$ (no corn is directly used in the production of gold), or if it is accepted that the industrial rate of profit alone falls temporary under the agricultural rate. On the contrary, it is assumed here that the price of corn has increased only to the extent that the industrial profit rate remains at the level of the agricultural profit rate. As a result, whereas the increase of the price of corn is a response to the fall of agricultural productivity, aiming at thwarting the threat of a decrease in profitability, this rise is limited by the conditions of production in the industrial sector.

At date t, prices $\tilde{p}^t$ and the profit rate $\tilde{r}^t$ are as such that:

$$\left(a_{11}^1 \tilde{p}_1^t + l_1^1 s^t\right)\left(1 + \tilde{r}^t\right) = \tilde{p}_1^t \qquad\qquad [7a]$$

$$\left(a_{21} \tilde{p}_1^t + l_2 s^t\right)\left(1 + \tilde{r}^t\right) = 1 \qquad\qquad [7b].$$

Beginning from the situation given by equations [5a]-[5b], process [6], [7a]-[7b] converges toward the state of the economy represented by equations [4a], [4b] et [4c], where prices and profit rates are p^1 and r^1 respectively [21]. Throughout this process, the profit rate decreases as a consequence as much as of an increase in wages ([6]), as of the change in the price of corn – which is likely to either fall or rise but in the latter case, more slowly than the money wage rate. The agricultural profit rate as such has had no decisive part in this [22]. However, once the process is over, the agricultural profit rate is indeed determined independently from prices and imposes itself, via the price of corn, on the entire economy. It is thus possible both to accept the strong proposition in a context of comparative statics and to reject it in a dynamic framework.

3. The Non-Debate Situation

From a scientific point of view, the debate could have ended up this way in 1975, after *Economica* let Samuel Hollander have the final word in the controversy setting him against John Eatwell and, through him, against the Sraffian interpretation of the *Essay*. Not that this debate was won outright by one or other of the parties. Indeed, there were neither winner nor loser: merely a clarification of the conditions likely to entitle each position to be maintained.

It could thus be considered that Sraffa's interpretation was likely to escape any objections raised against it provided that:

1. it was limited to the search for an objectivity of Ricardo's message, even if this was regardless of Ricardo's explicit words;

2. that comparative statics was confirmed as being the essential – if not exclusive – theoretical stake, so that the weak proposition might appear as a consequence of the strong proposition.

Contrary to this, Hollander's interpretation was acceptable provided that:

1. it aimed at determining the objective sought by a strategy of argumentation; possibly to the detriment of the accessory analytical constructions generated by this strategy;

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[21] See *infra*, Appendix.

[22] One might object that it is still possible to rewrite [7a] as $\left(a_{11}^1 \tilde{p}_1^t + l_1^1 c^t \tilde{p}_1^t\right)\left(1 + \tilde{r}^t\right) = \tilde{p}_1^t$. In such a case, the agricultural profit rate might seem independent from prices. However, contrary to w, the purchasing power of wages in terms of corn, c^t, is not given, but calculated on the basis of the money wage rate and of the price of corn. As a result, the agricultural profit rate can still not be considered independent from prices.

2. Ricardian dynamics were favoured – which, as we have noted, should exclude the strong proposition, even if its existence would have readily been granted within the context of comparative statics.

Certainly it remained feasible to reproach Hollander with having neglected Ricardian objectivity and comparative statics, Sraffa or Eatwell with having neglected Ricardian rhetoric and dynamics. This double negligence was, however, deliberate and could not, even today, be settled. Both on methodological and on analytical grounds, Sraffa-Eatwell's and Hollander's interpretations have too little in common to give rise to an actual debate likely, at least in principle, to give rise to a solution [23]. They depict two alternative views on the way Ricardo contributed to the constitution of the canon of Ricardian economics. So that they enter in conflict – and this one should be ranged among the most merciless – just because they exist, not because they intersect. The debate has ceased since there is no room for it. But there is still no reason why the conflict should die.

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[23] Such would not be the case, of course, for a controversy between authors whose methodological and analytical approaches share common grounds. An interesting example is given by T. Peach [1993], who both adheres to Sam Hollander's rejection of the corn-profit interpretation of the *Essay*, but nonetheless challenges his historical reconstruction.

Appendix – Hollander's case: behaviour of [6], [7a] and [7b] [24]

Let [6], [7a] and [7b] be rewritten as follows, omitting the superscripts on the variables:

$$\dot{s} = k\left(w\tilde{p}_1 - s\right) \qquad (k>0) \qquad \text{[6]}$$
$$\left(a_{11}\tilde{p}_1 + l_1 s\right)\left(1+\tilde{r}\right) = \tilde{p}_1 \qquad \text{[7a]}$$
$$\left(a_{21}\tilde{p}_1 + l_2 s\right)\left(1+\tilde{r}\right) = 1 \qquad \text{[7b].}$$

1. **Relation between the variation of the money wage rate ds and the variation of the profit rate d$\tilde{r}$:**

$$[7a] \Rightarrow \mathrm{d}\tilde{p}_1 = (1+\tilde{r})\,a_{11}\,\mathrm{d}\tilde{p}_1 + (1+\tilde{r})\,l_1\,\mathrm{d}s + (a_{11}\tilde{p}_1 + l_1 s)\,\mathrm{d}\tilde{r}$$
$$[7b] \Rightarrow 0 = (1+\tilde{r})\,a_{21}\,\mathrm{d}\tilde{p}_1 + (1+\tilde{r})\,l_2\,\mathrm{d}s + (a_{21}\tilde{p}_1 + l_2 s)\,\mathrm{d}\tilde{r}.$$

Eliminating $\mathrm{d}\tilde{p}_1$:

$$\left(\frac{(1+\tilde{r})l_1}{1-(1+\tilde{r})a_{11}} + \frac{(1+\tilde{r})l_2}{(1+\tilde{r})a_{21}}\right)\mathrm{d}s + \left(\frac{a_{11}\tilde{p}_1 + l_1 s}{1-(1+\tilde{r})a_{11}} + \frac{a_{21}\tilde{p}_1 + l_2 s}{(1+\tilde{r})a_{21}}\right)\mathrm{d}\tilde{r} = 0$$

or,

$$\alpha\,\mathrm{d}s + \beta\,\mathrm{d}\tilde{r} = 0.$$

Let R – which may be interpreted as the physical rate of reproduction of corn – be the solution of $(1+R)\,a_{11} = 1$. Assume that $R>0$, which means that the agricultural sector produces a surplus in corn. Now, if $0 < \tilde{r} < R$, it is obvious that $1 - (1+\tilde{r})\,a_{11} > 0$ and, consequently, that $\alpha, \beta > 0$. It follows that the signs of the variation of the profit rate d$\tilde{r}$ and of the variation of the money wage rate ds are the same.

2. **Relation between the variation of the variation of the real wage rate dc and the variation of the profit rate d$\tilde{r}$:**

Recalling that $c = \dfrac{s}{\tilde{p}_1}$, [7a] and [7b] can be written under matrix form as follows:

$$\begin{bmatrix} a_{11} + l_1 c & 0 \\ a_{21} + l_2 c & 0 \end{bmatrix}\begin{bmatrix} \tilde{p}_1 \\ 1 \end{bmatrix} = \frac{1}{1+\tilde{r}}\begin{bmatrix} \tilde{p}_1 \\ 1 \end{bmatrix}.$$

Now, since $\dfrac{1}{1+\tilde{r}}$ is the dominant eigen-value of the matrix in the left-hand member of the above equation, it is a non-decreasing function of the elements of this matrix and, more precisely, an increasing function of c. This means that the sign of the variation of the profit rate d$\tilde{r}$ is the opposite of the sign of dc, the variation of the purchasing power, in terms of corn, of the money wage rate.

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[24] The notations of the appendix and the references of the equations are the same as above, § 2.3.

3. Convergence of the real wage rate *c* to the normal real wage rate *w*

From the definition of *c*, it is obvious that [6] can be presented in an equivalent form:

$$\dot{s} = k(w-c)\tilde{p}_1 \qquad (k > 0) \qquad \text{[6']}.$$

After the initial shock in agriculture at t_1, when a less fertile land had to be cultivated, the real wage was such that $c < w$. According to [6'], $ds > 0$. $d\tilde{r}$ is thus negative and dc positive. The real wage rate *c* will therefore increase until it becomes equal to the normal wage rate *w* which prevailed at t_0. This means that the price of corn, the real wage rate and the rate of profit in the process described by equations [6], [7a] and [7b] converge to a limit (where $\dot{s} = 0$) defined by the equilibrium values of prices and distribution in equations [4a] and [4b]:

$$\left(a_{11}^1 p_1^1 + l_1^1 s^1\right)\left(1 + r^1\right) = p_1^1 \qquad \text{[4a]}$$

$$\left(a_{21} p_1^1 + l_2 s^1\right)\left(1 + r^1\right) = 1 \qquad \text{[4b]}.$$

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