Theory of differential rent and capital heterogeneity: a neo-Ricardian analysis

This paper aims to show why Ricardo's theory of differential rent is a parable that highlights capital heterogeneity. Contrary to Marshall's interpretation, it is not possible to deduce the law of decreasing marginal return from such a law: the Sraffian interpretation is incompatible with that of Marshall, primarily with respect to (a) the measure of an aggregate quantity of capital and (b) the modalities of rent distribution.

Keywords: capital heterogeneity—law of diminishing returns—rent distribution.

Theory of differential rent and capital heterogeneity: a neo-Ricardian analysis.

Alain Herscovici [*]

"The question reflects the historical development of marginal productivity theory whereby, in a perfectly competitive economy and in the long-run equilibrium, the Malthusian and Ricardian theory of rent was extended to "factors of production" other than land" (Harcourt, 1972, p. 3)

1) In this article, I will attempt to reconstitute the epistemological trajectory that began with Ricardo's theory of differential rent and led to Sraffa's work and the Cambridge controversy.

Different concepts of the nature of capital are, in epistemological terms and in terms of history of economic thought, an important criterion of differentiation among different schools of thought. Keynes and Sraffa's conceptions, along with those of the neo-Ricardians, are completely different from and incompatible with the neoclassical conception, as emphasised by the Cambridge controversy. These differences have implications for the construction of aggregate production functions (MacCombie, Felipe, 2005), the nature of macroeconomic equilibrium, the processes of convergence towards a steady-state position and, finally, the modalities of rent distribution.

[*] Ph.D. in Economics from the University of Paris I Panthéon-Sorbonne and Amiens, Coordinator of the Study Group in Macroeconomics (GREM) of the Master's in Economics at UFES, Titular Professor of the Department of Economics and Master's in Economics at UFES and CNPQ researcher (e-mail: alhersco.vix@terra.com.br).

For these reasons, the Keynesian and neo-Ricardian schools[1] emphasise the heterogeneous character of capital[2] and thus the logical impossibility (a) of conceiving an amount of aggregate capital as a constant value and (b) of deducing from the value of this capital the remuneration of factors of production.

2) This article aims to demonstrate that according to Ricardo's theory, capital is conceived as a heterogeneous factor of production. For this purpose, I will begin my demonstration from Ricardo's original theory. This theory constitutes a *parable:* it is not limited to the analysis of agricultural production, but it provides the first elements of a theoretical construct in which capital is heterogeneous, thus announcing the Cambridge controversy.

Marshall's reading of the Ricardian theory is based on a homogeneous conception of capital. This interpretation sees in Ricardo the precursor of the neoclassical school: his theory of differential rent is conceived as a marginalist analysis in which marginal costs are increasing and in which the producer equals marginal cost and revenue. In this work, I will emphasise the limits of that interpretation.

3) In the first part of this paper, I will explain the basic mechanisms noted by Ricardo regarding the theory of differential rent. In the second part, I will compare Ricardo's analysis to Marshall's interpretation and show why the latter is incompatible with Ricardo's original analysis. In the third part, I will show how Sraffa extends Ricardo's analysis to the economy as a whole and to what extent this extension implies a refutation of the architecture of neoclassical macroeconomics.

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[1] Not only Sraffa but also Keynes had already begun to develop such an analysis. See Herscovici (2013) and Rotheim (1988).

[2] For this reason, in his growth model, Solow (1956) reasons from an economy that produces a single good.

I) Ricardo's analysis: a first approach

1) *Ricardo's model: hypothesis and overview*

1.1 *"Capital" heterogeneity: a first approach*

The model is conceived based on an economy that produces a single good: corn. Added value is defined by the surplus of corn obtained at the end of the period considered based on the following reasons. First, advances[3] made by the capitalists are composed of wages and circulating capital. Second, at the end of the period, the revenue obtained allows the reconstitution of the circulating capital, the payment of wages, the earning of an average profit and the eventual payment of the landowner's rent. All the variables are evaluated in corn quantities:

> "On the land first cultivated, the return would be the same as before, namely, fifty per cent. or one hundred quarters of corn; but, the general profits of stock being regulated by the profits made on the least profitable employment of capital on agriculture, a division of the one hundred quarters would take place, forty-three per cent. or eighty-six quarters would constitute the profit of stock, and seven per cent. or fourteen quarters, would constitute rent." (Ricardo, 1821, p. 53).

The production function can be represented as follows:

$$Y = \varphi \, [\mathrm{T}, (\mathrm{l}, \mathrm{c})] \qquad\qquad (1)$$

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[3] "Advances" is used in the sense employed by Quesnay.

T represents the cultivated land; (l, c) represents the composite factor, namely, labour and circulating capital. Hypothetically, in an economy that produces a single good, *l* and *c* are obligatorily homogenous because they are evaluated in terms of the quantity of corn.

The problem of heterogeneity relates to the different qualities (i.e., different fertilities) of lands, which translates into different productivities. As Ricardo supposes, the fact that lands have different qualities means that *T, in equation (1) is heterogeneous. T* is composed of lands with different qualities (productivities): t_1, t_2, ..., t_n.

We observe here elements from which the works by Sraffa and the neo-Ricardian school developed (Robinson, 1953-54). The Cambridge controversy emphasises the logical impossibility of measuring an aggregate amount of capital independent from the value of the distributive variables[4]. This result is incompatible with the neoclassical theory of rent distribution: the remuneration of the factors of production is not determined from their respective contributions to the product (Idem).

From a logical point of view, it is impossible to calculate the marginal productivity of capital for the following reasons: the definition of marginal productivity (Kmp) of capital is as follows:

$$Kmp = \Delta Y / \Delta K \qquad (2)$$

(Kmp as the capital marginal productivity, Y as the total product and K the total capital: Δ is related to variations.)

This marginal productivity is equal to the interest rate, which is equal to the rate of profit (Garegnani, 1980). Because capital is a heterogeneous good, it must be expressed in value terms. This expression in value terms is a logical impossibility: to assess the marginal

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[4] For a retrospective synthesis of this problem, see Cohen and Harcourt (2003).

productivity of capital in value terms (and thus the rate of profit), it is necessary to know K and Y in value terms in advance; but to know K and Y in value terms, it is necessary to know in advance the rate of profit embedded in K and Y. In other words, to calculate the rate of profit, it is necessary to know this same rate of profit in advance. *Because one of the factors of production is heterogeneous, the concept of marginal productivity of this factor no longer makes sense.*

1.2 *The production function used by Ricardo*

In light of these preliminary observations, I will interpret Ricardo's theory of differential rent based on the concept of decreasing returns to scale (Sraffa, 1926, p.540 and 541):

Constant marginal productivity on land t_1: $\Delta Y t_1 / \Delta (l, c) = $ constant.

--t_2: $\Delta Y t_2 / \Delta (l, c) = $ constant.

Returns to scale are constant when we consider land homogeneity[5]:

$$\alpha Y i = \varphi [\alpha (l, c), \alpha t i] \qquad (3)$$

with $\alpha > 0$.

Returns to scale are decreasing when we consider land heterogeneity, i.e., different land qualities:

$$\alpha^\beta . Y = \varphi [\alpha (l,c), \alpha t i] \qquad (4)$$

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[5] Kalecki [(1990), p. 83] generalizes this hypothesis: he claims that in the industry, as the firm does not use its entire production capacity, marginal costs are constant

With $\alpha > 0$ and $0 > \beta > 1$.

Thus, the necessary and sufficient condition for the mechanism noted by Ricardo to occur is the existence of land heterogeneity; this mechanism operates fully without invoking the law of the diminishing marginal productivity of the factors of production. Such approach is confirmed by Ricardo in his *Principles* : « It is, then, because land is not unlimited in quantity and uniform in quality (...) that rent is ever paid for it » [Ricardo, 1821, p. 41]; land heterogeneity explains the increase of production costs and, consequently, decreasing returns. The "well-behaved" Cobb-Douglass functions are characterised by constant returns to scale (Kaldor, 1972); this constitutes a fundamental difference between the Ricardian analysis and the neoclassical analysis.

2) *The Ricardian model: the main mechanisms*

2.1 *The ricardian mechanism*

Sraffa´s analysis allows to distinguish two reasons to justify diminishing returns (1960, p. 238): diminishing returns are *extensive* when land is *heterogeneous*; returns are *intensive* when the quality of the land is constant; the increase of supply translates in the use of less productive methods of production (Idem). *These two situations are equivalent, since in both cases the increase in the unit value of the goods produced is due from the heterogeneous nature of land or capital.* Thus, the mechanisms highlighted by Ricardo and the neo-ricardian school fully work when one of the factors of production is heterogeneous; such heterogeneity may be related to land or capital.

Change in the capital-labour ratio is an epiphenomenon, regarding the justification of diminishing returns: in this regard, Sraffa says that "(...) the essential is the change in the absolute size of the set of factors employees, then it is possible that their relationship does not

vary "(Sraffa, 1925, p. 37, pp. 53-54). Thus, for each dose of the composite factor applied to a land of the same quality, the unit production costs are constant (and not increasing, as Marshall guesses).

It is also important to draw a parallel with the analysis of Keynes in the General Theory (GT). Keynes shows that there are different qualities of capital, each one with different marginal efficiencies; then in a second time, the marginal efficiency of total capital decreases with the total amount of capital used (Herscovici, 2013). This decrease in the marginal efficiency of capital means that, since the total quantity of capital increases, the system will make use of capital of "lower quality"; this mechanism acts as long as the marginal efficiency of capital is greater than the interest rate.

Such mechanism corresponds to the two problems studied by Sraffa: (a) the heterogeneity of capital, according to its different marginal efficiencies, and (b) the fact that such increase in production makes necessary to use capital of "worst" quality.

2.2 *The main results*

The following observations must be made regarding land rent:

i) Rent is not productive because it does not create value: *the rent is tied to the property, not to labour, the only source of value.*

ii) Rent appears and its value increases due to the scarcity of land of better quality: *this scarcity turns the capital heterogeneous.*

iii) Because this is an economy with a single good, differences in the "physical" productivity of lands of different quality do not change over time. The rent reflects a change in the modalities of distribution of the total value created by labour; consequently, it represents a

cost that the capitalist must assume. Because value creation is entirely explained by direct and indirect amounts of labour, land itself does not create value.

According to Ricardo's theory, there are antagonisms among different social classes; more precisely, when wages rise, profits must decrease, and when land rent increases, profits also decrease. This result is completely incompatible with the walrasian theory of productive services, according to which the remuneration of each factor is equal to its contribution to the product; this theory excludes, by definition, such distributive conflicts.

The marginal term does not refer to the ratio of the production factors (the capital-labour ratio in the standard neoclassical theory), but to the heterogeneity of the capital composed of different lands; from such a perspective, the marginal land is that which (a) determines the single price of corn, and (b) is not subject to private ownership because its production costs are so high that they would not allow the payment of rent to its owners (Schumpeter, 1983, vol. II, p. 397 and 398).

In neoclassical economics, the equalisation of the rate of profits is explained by the fact that different firms have the same structure of costs and revenues, equal marginal costs and marginal products. For example, according to the theory of contestable markets (Baumol, 1982), if a firm earns a profit π with a price above its marginal cost, performing a production y, this is an opportunity for *outsider* firms: such firms will enter the market offering a quantity $y + \xi$ and thus earn a profit of $\pi + \Delta \pi$. The competitive mechanism connected to the contestability of markets implies an increase in the amount produced, the disappearance of this rent and the return to the Pareto optimum. This auto-regulation mechanism acts when the amounts produced vary and when firms have the same cost structure.

In Ricardo's analysis, the equalisation of the rate of profit is explained by the fact that capitalist firms have different cost structures (the rent to be paid is different, depending on the different land qualities), and average and marginal productivity are also different [6]. *The total production is exogenous; it cannot be conceived as an adjustment variable that allows the restoration of competitive conditions.*

As Ricardo states, price increases when it is determined by the conditions prevailing in lands of poorer quality. Consequently, the average cost obligatorily increases because lands with lower productivity are incorporated into the productive structure. The increase in the average cost is determined from the following mechanism: to the extent that by definition, $y_1 > y_2$ and $TC_1 = TC_2$, $AC_1 < AC_2$ (yi represents land production *i,* TCi the total cost and ACi the average cost). This result is completely independent of the law of diminishing marginal productivity; this increase in the average total cost is explained by the heterogeneity of the land.

The productivity of land 1 is constant for all times considered; during the first period, only land 1 is cultivated (segment OA in Figure 1).

During the second period (BC segment), lands t_1 and t_2 are cultivated; the productivity of t_2 is, by definition, lower than the productivity of t_1. During this second period, the productivity of t_1, measured in amount of corn per unit of capital, is constant. *The productivity differential is explained by the scarcity of better-quality land*; scarcity explains (a) why inferior quality lands must be cultivated and consequently, (b) why there is a difference in costs. The rent appears (ABCD area) as a function of the average productivity differential between t_1 and t_2.

Figure 1: *Ricardo´s model*

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[6] Sraffa (1960, pp. 238, 239) comes to this conclusion.

marginal
costs

1

2

B

C

mc₁.₂

mc₂.₂

p₂

O

mc₁.₁

A

D

p₁

y₁

y₂
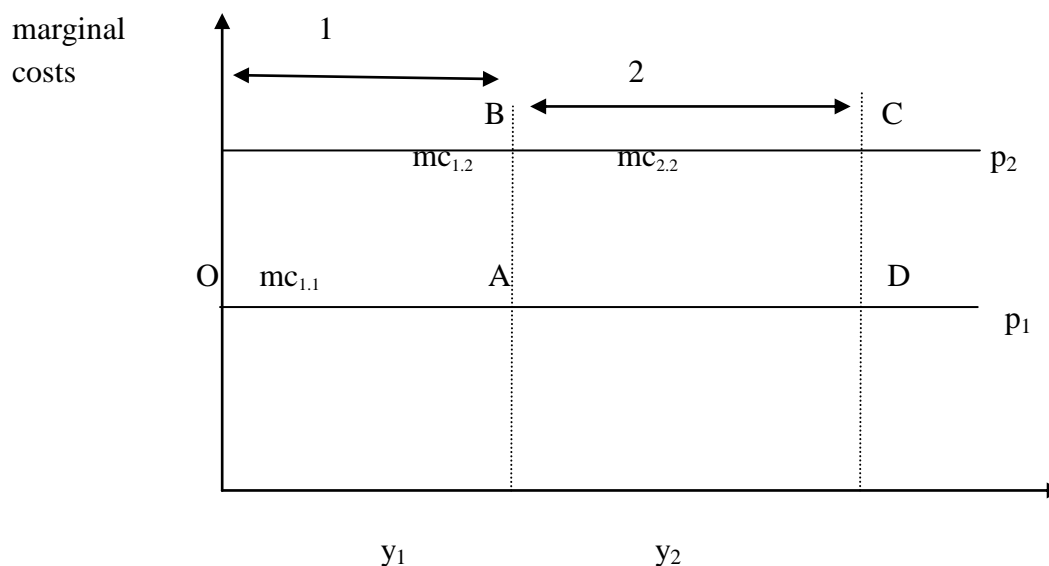
II) Ricardo and Marshall: two incompatible interpretations

**1)** *Marshall´s analysis*

1.1 *The "land switching"*

With respect to Ricardo's theory of differential rent, Marshall states, "(...) Our law establishes that sooner or later (....) a point will be reached after which all additional doses [of the composite factor] will obtain a lower yield in proportion to the preceding doses." (Marshall, 1920, p. 145).

This interpretation allows the statement that the extensive conception obligatorily originated from the intensive concept (Jessua, 1991, p. 188): *in a land of equal quality,* the increase in the composite factor corresponds to a decrease in the supplementary product. *The application of a supplementary dose, beyond a certain value, would result in a deficit of exploitation with a higher marginal cost than the marginal revenue (mc₁.₂ in Figure 2); the fact of cultivating*

inferior-quality lands allows one, momentarily, to keep the marginal cost at such a level that capitalist exploitation will generate a profit.

The point at which an (increasing) marginal cost becomes equal to the marginal product is defined based on a critical value of the ratio C/ti. For this reason, the Marshallian concept used in neoclassical theory is intensive.

Figure 2 The Marshallian analysis and the "exchange" of lands
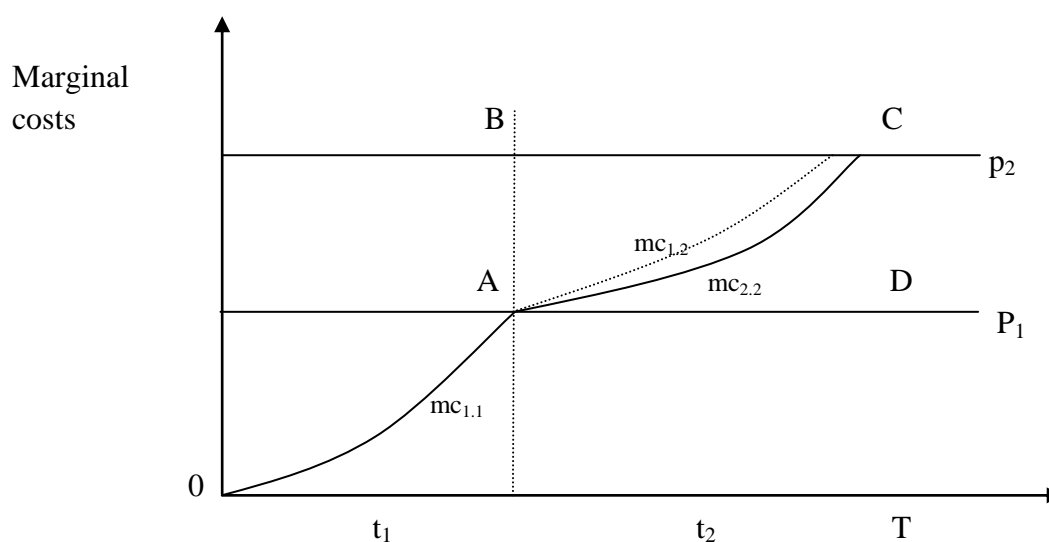
$mc_{1.1}$ represents the marginal cost of land 1 during period 1, and $mc_{1.2}$ represents the marginal cost of land of quality 1 in period 2, as the ratio C/ti increases, *in the same land,* in the second period. This does not occur because the capitalists exploit lands of inferior quality in this second period. Rather, *this mechanism implies that there is an update of the costs and unit prices depending on the different periods considered:* the cost of the production realised on land 1 in the second period is equal to $mc_{1.1} + R_{1.2}$, which is equal to $mc_{2.2}$. The marginal cost curve of the total capital is represented by the solid line curve $mc_{1.1}$ and $mc_{2.2}$.

From West (1815) to Marshall (1982) and Blaug (1986), we find the following arguments:

(a) Capitalists stop investing on land of a given quality when an increase in the C/T ratio makes their marginal costs higher than the marginal productivity obtained from the land. That is why they exploit a land of inferior quality: there, *the lowest yield of T will be compensated by the fact that the marginal cost is lower than the marginal productivity of C; this mechanism allows the momentary restoration of the rate of profit in the land of inferior quality:* (Wetz, op. cit., p. 14): $c_2/t_2 < c_1/t_1$, which implies $mc_{2.2} < mc_{1.2}$ (cf. Figure 2).

(b) *Diminishing marginal productivity implies that average productivity is also diminishing* (Blaug, 1986 p. 90). On lands with quality t_1, c/t_1 increases until the marginal cost is equal to the price (or marginal product); on land t_2, the amounts of capital will gradually increase until c/t_2 equals the price. Because the average productivity in t_2 is obligatorily lower than the average productivity in t_1, as Marshall states, the theory of differential rent is explained based on the law of diminishing marginal productivity; Marshall states, with respect to the rent generated by adding a dose of labour and capital, that "(...) it does not matter if it is applied to a poor or to a rich land; it is sufficient that it is the last dose that can be applied profitably to this land" (op. cit., p. 146).

1.2 *Marshall versus Ricardo*

The Marshallian interpretation obligatorily verifies the following relationships:

$$mc_1 = \varphi_1\,(c_1/t_1), \quad \text{with } \varphi_1{}' > 0 \qquad (5)$$

$$mp_1 = \varphi_2({}^{c_1}/_{t_1}), \quad \text{with } \varphi_2{}' < 0 \qquad (6)$$

$$mc_2 = \varphi_3\,(c_2/t_2), \quad \text{with } \varphi_3{}' > 0 \qquad (7)$$

$$mp_2 = \varphi_4\,(\,c_2/t_2), \quad \text{with } \varphi_4{}' < 0 \qquad (8)$$

(mci is the marginal cost in land i and mp_1 is the marginal productivity of i).

The observation of Figure 2 shows that at the beginning of the first period, c_1/t_1 increases until the marginal cost is equal to p_1. The *"land exchange"* occurs at this point. Capitalists apply increasing amounts of the composite factor on land 2 until $mc_{2.2} = p_2$. I will call the equilibrium point the situation in which on a land of given quality, the marginal cost of the composite factor equals its marginal productivity. The equilibriums of two periods correspond to the following situation:

Period 1 $mc_{1.1} = p_1$ (9)

Period 2 $mc_{1.1} + R_{1.2} = p_2 = mc_{2.2}$ (10)

($R_{1.2}$ is the rent that the capitalist must pay for land 1 at period 2).

Proposition 1

The factors of production are considered fully substitutable; this allows for building "well-behaved" macroeconomic production functions and implementing mechanisms of convergence towards a steady-state position in the models of economic growth. (Harris, 1978).

The Marshallian interpretation is contradictory. The validation of the law of diminishing marginal productivity, or of increasing marginal cost, for a heterogeneous set implies the following modification of equations (5)-(8):

$$mc = \varphi_5 \left(\frac{C}{t_1 + t_2} \right) = \varphi_5 \left(\frac{C}{T} \right) \qquad (11)$$

$$mp = \varphi_6 \left(\frac{C}{t_1 + t_2} \right) = \varphi_6 \left(\frac{C}{T} \right) \qquad (12)$$

In this case, if T is heterogeneous, the law of increasing marginal costs is not tested, in a continuous way, for each type of land.

Proposition 2

Based on equation (10), it is possible to deduce that at equilibrium:

$$mc_{1.1} < mc_{2.2} \qquad\qquad (13)$$

If, as assumed by the neoclassical analysis, returns to scale are constant, relationship (13) obligatorily implies that *this difference is explained by a difference of capital intensity on both types of land.* In figure 2, A represents the first point of land exchange: at A, there is profit maximisation; between B and C, $mc_{1.2} > mc_{2.2}$, the capitalist exploiting land 2 will increase the amount of the composite factor until arriving at C. Because the price of corn is determined by the worst conditions of production, to the right of A, the price increases from p_1 to p_2; the AB portion represents the additional cost that the capitalist on land 1 must pay to the rent owner.

There is a fundamental ambiguity: the marginal costs increase for two reasons, not only because the C/T ratio increases in a land of equal quality but also because it is necessary to exploit lands of poorer quality. It is the increase in production that generates (a) an increase in the price of corn, (b) an increase in the average cost and (c) an increase in the costs of scarce lands in the form of differential rent. As emphasised by Sraffa (1925, p 24), there is no way to differentiate the impact of these two effects on average productivity. On the other hand, *it is impossible to think in terms of marginal cost when one of the factors of production (T) is not homogeneous*. Finally, while the different lands are not exhausted (before A and D), the capitalists act as a monopoly, with the price above the marginal cost (Sraffa, 1926).

This reading is inconsistent with Ricardo's theory, which argues as follows:

i) *There is an update of the marginal cost for land 1,* depending on the period considered. In the second period, the cost to exploit better-quality lands is mc $_{1.1}$+ R$_{1.2}$ (Eq. (10)); this difference is explained based on the rent that the capitalist must pay, R$_{1.2}$ (Herscovici 2013).

ii) The land is not a homogeneous factor of production; *the substitution of factors of production is, by nature, limited;* consequently, we can thus consider that the coefficients of production are fixed (Dockès, 1971). Equations (5)-(8) are not verified for lands of different quality. *It is impossible to reconcile, as Marshall does, land heterogeneity and the law of diminishing marginal productivity (or the law of increasing marginal costs):* land heterogeneity limits the substitutability of the factors for land of equal quality, and this substitutability cannot be applied to a heterogeneous set of lands.

It is possible to draw a parallel with the *reswitching* of techniques; if we consider that land heterogeneity is equivalent to heterogeneity of the production methods used (Sraffa, 1960, p. 238), we find the same type of limitations as those highlighted by the Cambridge controversy: the monotonic relationship between C/T ratio (the capital/labour ratio in the controversy) and the marginal productivity (the interest rate in the controversy) is not verified for any value of C/T.

The Marshallian analysis is explained based on an *intensive* conception because the marginal productivity of the factors depends only on the C/T ratio, regardless of the production scale. This production scale has no influence on the average returns because the returns to scale are constant. For this law to be applicable, the factors of production must be fully substitutable and therefore homogeneous. It is the reason why Schumpeter states that theorists assimilating Ricardo's theory of differential rent into the theory of marginal productivity of factors of production "(...) do not generalise Ricardo's scheme but instead destroy it" (Schumpeter, 1983, p. 7 39).

Ricardo's analysis includes an *extensive* concept of marginal cost and marginal productivity; likewise, in Keynes's economy, what matters is capital heterogeneity, not the C/T ratio (Pasinetti, 1997). As Sraffa states, the "law" of diminishing marginal productivity is primarily explained by the "increasing size of the branch of activity (...)" (1925, p. 24), not by modifying the proportion of the quantities of the two factors. In this regard, he states, "(...) the increase in the size of the branch of activity could also be the result of an increase of all factors of production" (Id.)

2) *Marshall´s these: the equivalency between quantities and values*

Equivalency between values and quantities is the fundamental assumption that allows to constructs neoclassical production functions and thus determines the main relationships of neoclassical macroeconomics. The scarcity of production factors is assessed by physical quantities: in the Cobb-Douglas function , which is written in the form $Y = f(K, L)$, K represents the capital quantity and L the labour quantity.

Marshall´s contradiction may be expressed in the following terms: on one hand, equivalence between values and quantities constitute the foundations of the neoclassical analysis; such equivalence is only possible when returns of scale are constant. On the other hand, returns of scale constant imply in land homogeneity. *It is not possible to verify simultaneously the equivalence between values and quantities and the heterogeneity of the land; in other words, the heterogeneity of the land (and by extension of the capital) does not allow to deduce such equivalence; the Cambridge controversy will develop this analysis.*

Figure 3 *The homogeneity land hypothesis*
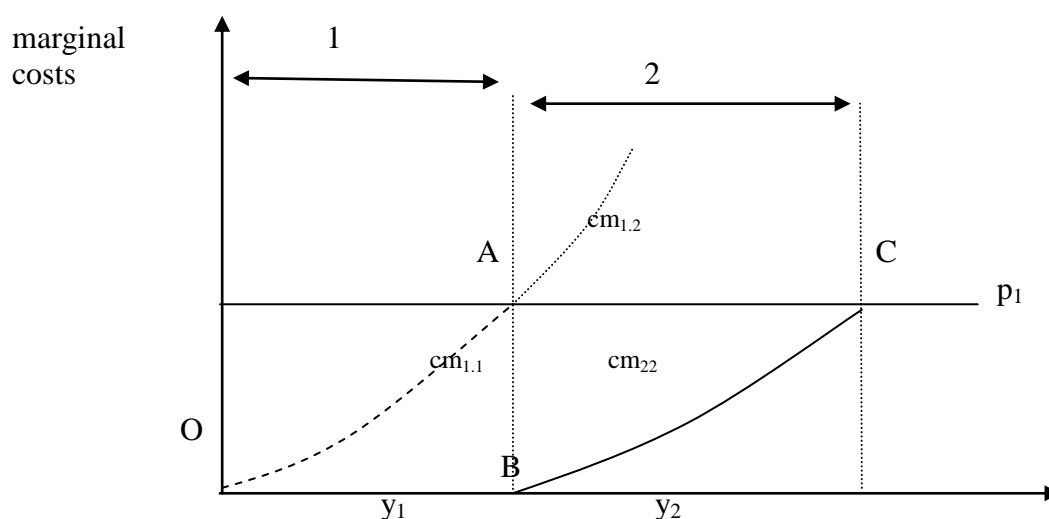
yi as the quantities produced on an amount of land *i*, during the period 1, $cm_{1.1}$ as the marginal cost of land 1 for the period 1, $cm_{1.2}$ and the marginal cost of land 1, when y_1

increases on land 1 during the period 2. On land 2, the C / T ratio increases until the marginal

cost equals marginal revenue.

If ACij represents the average cost of corn obtained on land i in period j, $c_1 + c_2 / y_1 + y_2$ is

equal to c_1 / y_1.

$$AC_{1.1} = AC_{1.2} = AC_{2.2} \qquad (14)$$

ci as the quantiy of composite factor used during period i, yi as the land of quality i

cultivated, and ACij as the corn average cost on the land i during period j.

Equation (14) is expressed in terms of "physical" quantities, i.e. say in corn quantities.

The average cost on land 1, evaluated in quantity of corn, is the same in both periods;

'physical' productivity is constant on all periods considered. The law of constant returns of

scale imply that the unitary value of corn, evaluated from labour quantity, during the two

periods considered, is equal to *qi*. The average value is constant over the two periods

considered:

$$qi. AC_{1.1} = qi. AC_{1.2} = qi. AC_{2.2} \qquad (15)$$

Equations (14) and (15) allow to assert that, when costs evaluated in physical units are

constant, they are also constant in value; it is possible to note *an equivalence and a*

proportional relationship between physical quantities and values, which corresponds to the

marshallian hypothesis used by neoclassical economics.

When, on the contrary, returns of scale are decreasing, the unitary value of corn, measured

by the quantity of labour, increases with the exploitation of poorer quality land: q_1 is

necessarily less than q_2. The equation in physical units (that is to say in quantities) can be written as follows:

$$AC_{1.1} = AC_{1.2} < AC_{2.2} \qquad (16)$$

because physical productivity of land 1 is constant. The equation in value changes as follows:

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$$q_1 . AC_{1.1} < q_2 (AC_{1.2} + R_{1.2}) = q_2 . AC_{2.2} \qquad (17)$$

(R as the land rent that the capitalist who cultivates the best land has to pay the landowner during the period 2).

In the Ricardian system, this equivalence between quantities and values is not checked when the land is heterogeneous. The quantity of corn produced on the land 1 is the same in both periods. Nevertheless, these same quantities, measured in value, are different depending on the period considered, and this for the following reason: *the value of the average cost of land 1 is updated during the period 2*. This updating mechanism is performed based (a) on the increase of corn value and (b) on the payment of land rent which adds to production costs. Comparing (16) and (17) shows that there is no equivalence between quantities and values:

> « It is true that, on the best land, the same ´produce will still be obtained with the same labour as before, but its value would be enhanced in consequence of the diminished returns obtained by those who employed fresh labour and stock on the less fertile land" [Ricardo, (1821), p. 44]

The hypothesis of constant return of scale is necessary to prove the equivalence between quantities and values; nevertheless, it is incompatible with the ricardian rent, because such rent comes from the land productivity differential, i.e., land heterogeneity.

Ricardo's analysis is performed at aggregate level (C/T or C/Y), returns are constant at the microeconomic level, and decreasing at the aggregate level; it highlights why land heterogeneity explains the modification of corn value over different periods. Marshall's analysis is essentially microeconomic (ci/ti), returns are decreasing at the microeconomic level and constant at the aggregate level. Marshall postulates homogeneity of production factor, which implies that the value of corn is constant. The "reductionism" Marshallian is expressed by the primacy of the microeconomic analysis, that is to say, by the fact of reducing the overall macroeconomic mechanisms to their microeconomic foundations: in this sense, Marshall´s contribution is essential to design the neoclassical standard macroeconomics.

There is an extension of these parables to other forms of capital: the neoclassical school, from Marshall's work, conceive capital as homogeneous, allows it, among other things, to justify the Cobb-Douglas production functions, and to explain the distribution of revenues from the scarcity of factors of production as measured by the capital / labour ratio, the latter being assessed by quantities. The neoricardian school highlights the heterogeneity of capital, which leads to a refutation of all the neoclassical macroeconomic relationships, from a different concept of scarcity.

III) Sraffa's contribution

1) *The nature of scarcity and rent distribution*

For Ricardo, population increase and the "development of society and wealth" (1821, p. 97) explain why it is necessary to cultivate lands of inferior quality; this translates into an increase in costs, which explains the appearance of land rent. Thus, the law of diminishing returns is explained based on an economic cause, not a physical one (Sraffa, 1925, p 37); scarcity is by nature social and is caused by different social and economic developments.

Scarcity appears due to the *exogenous* increase of production. This scarcity explains, in turn, increasing costs and decreasing productivity. *Ricardo provides an economic definition of scarcity* (Gregory, 1997, p 163.) *and an economic explanation of diminishing productivity,* "The characterisation of the Ricardian theory, acknowledged by us as fundamental, i.e., assigns an economic cause *rather than a physical cause* to the diminishing productivity (...)" (Sraffa, 1925, p. 37, emphasis added).

The logical sequence can be stated as follows: an *exogenous change in rent distribution* is translated into a change in the demand for corn. This increase in demand corresponds to land "heterogenisation", by increased costs and the need to exploit lands of inferior quality. Finally, this process is translated into a change in rent distribution: the relative share of rent and wages increase, whereas the relative share of profit diminishes.

At this point, the assumptions of the neo-Ricardian analysis appear: there is an exogenous determination of distributive variables, and this exogenous determination constitutes the cause

of scarcity and the increase in average costs. The value of a certain aggregate amount of capital cannot be measured independently of the value of distributive variables because with this mechanism, the value of the single good (corn) increases, which leads to an increase in the capital value, also measured in corn.

In neoclassical economics, the scarcer a production factor, the higher its price and the greater the part of wealth attributed to the holders of that factors (Harris, 1978). The modalities of rent distribution can be explained by the C/T ratio; in Ricardian economics, causality is reversed: the initial rent distribution generates a scarcity of certain factors, an increase in production costs and a transfer of rent from capitalists to rent landowners.

Table 1: *Scarcity, production costs and distribution*

Neoclassical economics: physical scarcity $\rightarrow$ prices of production factors $\rightarrow$ rent distribution. Variations in production allow the maintenance of conditions for profit maximisation. *Scarcity is physical: it is the key variable*.

Ricardian economics: economic development $\rightarrow$ initial rent distribution $\rightarrow$ scarcity $\rightarrow$ change in rent distribution. Variations in production are exogenous and do not constitute an adjustment variable for the position that corresponds to the maximisation of profit. *Scarcity is social: it is the variable determined.*

In neoclassical economics, price is determined based on the interaction of supply and demand; the construction of the supply function implies the adoption of the law of diminishing marginal productivity: only increasing marginal costs allow the construction of a well-behaved supply function and thus explain the price based on the interaction of supply and

demand (Sraffa, 1925, p. 46), and such construction is closely related to the utility theory of value. If this law of diminishing marginal productivity is not verified, then the interplay of supply and demand no longer explains the formation of prices (Id., p. 21).

In this case, the labour theory of value provides an alternative explanation that is based on direct and indirect labour costs. The classical economists, from Smith to Ricardo and Marx, showed that the interplay of supply and demand determines only temporary deviations between market prices and natural prices and that the former converge into the value of the latter. The determination of these natural prices (or in Marx's terminology, prices of production) is explained from the labour theory of value.

2) *The refutation of the neoclassical interpretation: a demonstration by Sraffa*

In his book "Production of Commodities by Means of Commodities", Sraffa (1960, p. 237 and following) explicitly refutes the Marshallian interpretation. He compares two situations: the first is characterised by the heterogeneity of lands, and the second is characterised by their homogeneity.

In the first case, the approach is *extensive* (id., p. 238) because the quality of the lands becomes "worse" due to increased production, i.e., there is a scarcity of better-quality land. *Sraffa considers that the situation in which the land is heterogeneous and the methods of production are homogeneous is equivalent to the situation in which the land is homogeneous and the methods of production are heterogeneous* (Ibid., p. 237). Thus, in the second case, various production methods are used simultaneously; to increase production, increasingly

less-productive methods will be required. There will thus be a difference in productivity between the different methods used[7].

For a particular method of production, the land has a limited production capacity: beyond this capacity, production methods allow the production of a greater quantity of corn but represent a higher unit cost (Ibid., p. 238). Because it is not possible to meet the increase in demand by exploiting lands of superior quality, it is necessary to resort to more "expensive" production methods; the rent appears in the land cultivated with the "cheaper" method.

This analysis can be applied to industrial production: excess in demand relative to supply creates a scarcity of certain goods. Their prices increase, which allows their production using either methods that are more expensive or methods that incorporate a larger amount of labour [8]. If the total production uses, for example, two production methods m_1 and m_2, with m_1 being that which corresponds to the smaller amount of labour per unit, and the price is determined based on m_2, there will be a differential in costs and rates of profit in that industry: firms that use m_1 will appropriate a quasi-rent, whereas those using m_2 will earn a lower rate of profit. Such a situation is incompatible with a situation of pure and perfect competition for the following reasons:

(a) Due to the fact that there is no equalisation of rates of profit, firms that use m_1 benefit from a monopoly rent because they do not equate their marginal costs with price.

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[7] This is the same case studied by Keynes (1990, p. 119).
[8] The parallel with the analysis made by Keynes in his general theory is obvious; in this regard, see Pasinetti (1997) and Herscovici (2013). In the Keynesian analysis, various qualities of capital operate during the same period.

(b) There is no mechanism linked to a component of supply that will make this rent disappear in the long run.

(c) The only factor that explains the existence and permanence of rents is scarcity, which is caused by an increase in social demand (Ibid., p. 239). Thus, the two situations analysed—land heterogeneity and homogeneity of production methods or land homogeneity and heterogeneity of production methods—are equivalent (Grégory 1997, p.160).

Proposition 1

Heterogeneity is manifested with respect to different qualities of land or to different production methods for the same land quality. In both cases, the situation is incompatible with the results of neoclassical economics: (a) Land heterogeneity does not allow for conceiving an aggregate amount of capital independently from the value of distributive variables (b) The heterogeneity of production methods does not allow for verifying the results of pure and perfect Walrasian competition, that is, the law of increasing marginal costs and the equalisation of marginal costs with marginal product

These two modes of heterogenisation allow the establishment of a parallel between Sraffa and Keynes. For Keynes, an exogenous decrease in the interest rate makes capitals that were previously unprofitable to become profitable (Pasinetti, 1997, Rotheim, 1988). *This implies that there is heterogeneity of production methods; consequently, capital cannot be conceived as a homogeneous factor* at the aggregate level, and the rule of equalisation of marginal cost and revenue is not verified.

Proposition 2

In both cases studied, we are in the presence of *decreasing returns to scale*; this characteristic is inconsistent with an aggregate production function of the Cobb-Douglas type, which is a new refutation of the aggregate production functions.

Proposition 3

This heterogenisation corresponds to an update of the capital value in each period: as the value of corn increases, capital value also increases. Thus, contrary to the neoclassical analysis, it is not possible to consider that the value of an aggregate amount of capital can be constant and determined independently from the distributive variables (see Figure 2).

Proposition 4

The Marshallian concept of increasing marginal costs only applies to the intra-marginal level, i.e., for lands of the same quality. The *tour de force* consists of extending this mechanism to the extra-marginal level, i.e., to lands of different quality. *In Ricardian economics, on the contrary, intra-marginal costs are constant and inter-marginal costs are increasing*, which proves that the latter do not depend on the former.

Proposition 5

Finally, it is possible to state that the neoclassical construct focuses on an analysis of the different components of supply and the mechanisms of self-regulation attached to them. In contrast, the distributive variables and the modifications resulting from demand play an active role in Sraffian analysis because these are the variables that cause scarcity.

Conclusion

It is not possible to interpret Ricardo's theory of differential rent as the assumptions of the marginalist school and its fundamentals, i.e., the law of diminishing marginal productivity, the equalisation between marginal cost and marginal revenue, and the determination of price based on the law of supply and demand. The interpretation provided by Sraffa shows that (a) the theory of differential rent can be explained without resorting to these laws and that (b) the results thus obtained are totally incompatible with the fundamentals of Marshallian economics.

It is also important to highlight the methodological convergences between Ricardo's method and results and those employed by Keynes in his General Theory. For Ricardo, Sraffa and Keynes, social scarcity explains profit and rent: (a) with respect to Sraffa's analysis, I showed that firms using the most efficient methods of production benefit from quasi-rent; and (b) for Keynes, an increase in investment during the same period causes various *vintages* of capital to coexist with differentiated returns (2009, p. 119). This mechanism is intrinsically linked to capital heterogeneity and the production methods used.

Finally, an aggregate amount of capital cannot be conceived using a value that is constant and independent from distributive or "expectational" variables. For the neo-Ricardian school, this is the subject of the Cambridge controversy; with respect to Keynes, a modification of long-term expectations is obligatorily translated into a modification of the value of this amount of aggregate capital (Herscovici 2013).

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