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Source: *Cambridge Journal of Economics*, Vol. 16, No. 1 (March 1992), pp. 43-53

Published by: Oxford University Press

Stable URL: <https://www.jstor.org/stable/23599755>

Accessed: 17-01-2022 19:37 UTC

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Ricardo's theory of tax incidence: a Sraffian re-interpretation

Takuo Dome*

1. Introduction

Ricardo was greatly concerned with the issue of taxation as well as that of value, distribution and growth. The title of his main work, *On the Principles of Political Economy and Taxation* (1817), supports this contention. Indeed, he devoted almost one-third of the chapters in the volume to the subject of taxation. Moreover, he criticised the fact that Malthus's *Principles of Political Economy* (1820) did not deal with this important subject. Ricardo wrote as follows in a letter to Trower in 1819:

I am sorry to find that Malthus, whose work I believe is now actually in the press, has left off, without treating on the subject of taxation. Political Economy, when the simple principles of it are once understood, is only useful, as it directs Governments to right measures in taxation. We very soon arrive at the knowledge that Agriculture, Commerce, and Manufactures flourish best when left without interference on the part of Government, but the necessity which the state has for money to defray the expenses of its functions, imposes on it the obligation to raise taxes, and thus interference becomes absolutely necessary. It is here then that the most perfect knowledge of the science is required, and I cannot but regret that Malthus has not given us his thoughts on this part of the subject. I hope he will immediately after publishing his volume seriously set about it (Sraffa (ed.), 1951–1973, vol. VIII, pp. 132–133).

Despite the fact that Ricardo discussed taxation as an important subject in economics, his theory of taxation has rarely been referred to compared with his theories of value, distribution, and growth. Even Hollander's massive volume on Ricardo (Hollander, 1979) has no explicit section on taxation, though it deals with issues of tax incidence on occasion. Shoup (1960) is the only comprehensive work on Ricardo concerning taxation that collects his statements from the letters, pamphlets and speeches as well as his *Principles*. An early treatment of Ricardo on tax incidence is seen in Whewell (1830 and 1833), who was the tutor of Ricardo's younger brother at Trinity College, Cambridge. Another Cambridge-related treatment of this subject is that of Marshall. In Appendix L of his *Principles of Economics* (1890), entitled 'Ricardo's Doctrine as to Taxes and Improvements in Agriculture', Marshall offers a critical comment on Ricardo's assumption of zero elasticity of demand for corn. He stated:

But the assumption that the demand for produce is absolutely inelastic is a very violent one. The rise in price would in fact be sure to cause an immediate falling-off in the demand for some kinds of

Manuscript received 29 January 1990; final version received 18 January 1991.

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produce, if not for the staple cereals: and therefore the value of Corn, i.e. produce in general, would never rise in full proportion to the tax, and less capital and labour would be applied in the cultivation of all lands. There would thus be a diminution in the Corn surplus from all lands . . .

It must be noted that Marshall re-interpreted Ricardo's theory of tax incidence by using the method of partial analysis with respect to a supply–demand balance. This approach has been conventional when referring to Ricardo on tax incidence. For instance, Hollander (1979, pp. 288–289), Musgrave (1959, pp. 385–392; 1985, pp. 32–35), and de Vivo (1987, pp. 195–196) follow this line.

On the other hand, Eagly (1983) tries to analyse the theory of tax incidence in Ricardo's system by using the uniform profit principle. However, his model assumed homogeneous units of composite factors for a production of commodities, and it does not generally analyse the repercussions among prices caused by tax shift. Consequently, it cannot disclose, in the light of reproduction theory, the coherence and the limitation in Ricardo's statement on tax incidence.

Ricardo did not always disregard the issue of reproduction structure in considering how a tax shift ultimately affected the economy. For instance, he recognised the effect of a tax levied on raw produce with respect to the prices of other commodities in the following way:

The probable effect of a tax on raw produce, would be to raise the price of raw produce, and of all commodities in which raw produce entered, but not in any degree proportioned to the tax . . . (Ricardo, 1817, p. 169).

. . . as the value of commodities is very differently made up of raw material and labour; as some commodities, for instance, all those made from the metals, would be unaffected by the rise of raw produce from the surface of the earth, it is evident that there would be the greatest variety in the effects produced on the value of commodities, by a tax on raw produce (*ibid.*, p. 171).

However, Ricardo left the domain of the reproduction system in darkness when pursuing the concrete economic effects of various taxations. He thought that any type of tax would raise the price of that commodity to the extent of the amount of the tax. Otherwise the producers of the commodity could not maintain a uniform rate of profits. If the commodity were consumed by labourers, however, money wages would have to rise in line with the increase in the price. This would lead to a decline in the rate of profit throughout the economy. Ricardo thus concluded that the ultimate incidence of taxes on commodities consumed by labourers would be carried by capitalists in all sectors. He thought that a tax on luxuries would not change the uniform rate of profits because labourers did not consume them (*ibid.*, pp. 243–244).

Thus Ricardo's reasoning does not allow for a reproduction system in which the output of corn is dependent upon the input of corn and steel, and the output of steel also needs the input of corn and steel. A tax on a commodity raises not only the price of that commodity to the extent of the amount of the tax but also the prices of other commodities whose production uses the commodity taxed as the input. These price rises will cause other changes, and the repercussions will finally form a new uniform rate of profit and a new relative price system. It must be stressed that we obtain this new price system through a reproduction structure in the economy as well as a change in the money wage.

To analyse precisely the effect of taxation on prices through a reproduction structure, it would be useful to apply the Sraffian formation of natural prices to the issues of tax incidence. Sraffa himself refers to this subject in discussing the difference between basics

and non-basics in his *Production of Commodities by Means of Commodities* (1960). He states:

A tax on a basic product then will affect all prices and cause a fall in the rate of profits that corresponds to a given wage, while if imposed on a non-basic it will have no effect beyond the price of the taxed commodity and those of such other non-basics as may be linked with it. This is obvious if we consider that the transformed system of Basic equations, which by itself determines the rate of profits and the prices of basic products, cannot be affected by changes in the quantity or price of non-basics which are not part of the system (p. 55).

This paper proposes to demonstrate how Ricardo's argument on tax incidence is complemented when we illuminate a reproduction structure by means of the Sraffian system. This approach is quite different from Marshallian analysis because it is concerned with natural prices determined exclusively by the reproduction structure, and not market prices determined by the supply–demand balance.

In Section 2, the assumptions and a basic model are presented. The model is the Sraffian system of three (necessity, raw produce, and luxury) sectors incorporating tax rates. In the Sections 3 and 4, we use the method of comparative statics to demonstrate how the uniform rate of profits and relative prices alter when each of the tax rates changes. In Section 4, we examine how various kinds of taxes affect money rent (rent measured in the numeraire, which is the nominal revenue of landlords) and corn rent (rent obtained by dividing the money rent by the price of raw produce).

Some of the results derived from this procedure are consistent with Ricardo's conclusions, but others make them invalid except in special cases which apply only under strict conditions.

2. Assumptions and the basic model

We suppose three sectors where necessities, raw produce, and luxuries are produced; we use necessities as the numeraire commodity.¹ We assume also that necessities and raw produce are utilised as inputs for the production of all commodities, and consumed by labourers, while luxuries are not. We consider taxes levied on commodity flows and income taxes on wages, profits, and rent.

We may represent the price system involving tax rates in the Sraffian mode of determination of prices and a uniform rate of profits as follows

$$1 = (1 + t_1) \left[1 + \frac{rt_r}{(1+r)(1-t_r)} \right] (1+r)[a_{11} + a_{21}p_2 + (1+t_w)(b_1 + b_2p_2)l_1] \quad (1)$$

$$p_2 = (1 + t_2) \left[1 + \frac{rt_r}{(1+r)(1-t_r)} \right] (1+r)[a_{12} + a_{22}p_2 + (1+t_w)(b_1 + b_2p_2)l_2] \quad (2)$$

$$p_3 = (1 + t_3) \left[1 + \frac{rt_r}{(1+r)(1-t_r)} \right] (1+r)[a_{13} + a_{23}p_2 + (1+t_w)(b_1 + b_2p_2)l_3] \quad (3)$$

Subscripts 1, 2, and 3 in the equations refer to necessities, raw produce, and luxuries respectively; p_2 and p_3 are the relative prices of raw produce and luxuries respectively, denoted by numeraire; r shows the rate of profits after tax; a_j and l_j represent the input

¹ Ricardo chose luxuries (representatively gold) as the numeraire commodity, and Eagly (1983) used the price of raw produce as the numeraire.

coefficients of commodity i and labour into sector j ; b_1 and b_2 are the quantity of necessities and raw produce consumed by a unit of labour, so $b_1 + b_2 p_2$ represents the money wages per worker. t_1 , t_2 , and t_3 denote the rates of tax levied on necessities, raw produce, and luxuries respectively. t_r is the rate of tax on profits. If capitalists attempt to shift forward the burden of the tax on profits, they have to raise the price of their commodity by¹

$$rt_r / [(1 + r)(1 - t_r)]$$

t_w shows the rate of tax on wages. In the above equations, it is assumed that capitalists bear the tax on wages and increase the price by the assessment.

In equations (1), (2) and (3), three endogenous variables i.e. p_2, p_3 , and r , are determined by the exogenous variables i.e. $a_{ij}, l_j, b_j, t_j, t_r$, and t_w ($i = 1, 2, j = 1, 2, 3$).

It is well known that, in the Ricardian system, the uniform rate of profits was argued to be achieved by an adjustment mechanism whereby capital moves between industries whenever rates of profit diverge. Ricardo thought that the adjustment mechanism would function also when a discrepancy in the rates of profit was caused by taxation. Following Ricardo, this paper supposes that the uniform rate of profits and natural prices are always realised by capital movements even if a change in tax rates temporarily disturbs them.²

We assume that the production of necessities and luxuries is subject to constant returns to scale while the production of raw produce is subject to diminishing returns because of the scarcity of land. Differential rent thereby exists only in the raw produce sector. Rent and a tax on rent do not appear in the price equation of raw produce shown by (2), since rent has no part in the formation of prices in the Ricardian system. a_{12}, a_{22} , and l_2 in equation (2) are the input coefficients with respect to the marginal land. The coefficients of the superior land must be smaller, and the difference in the revenue amounts between the marginal land and the superior land is paid as rent from capitalists to landlords.

The input coefficients with respect to the marginal land tend to increase (decrease) according to the expansion (contraction) in the production of raw produce. If diminishing returns are continuous, any small variation in the scale of the raw produce sector alters the input coefficients in equation (2). Conversely, if diminishing returns occur discretely, the input coefficients do not always alter with a change in the production scale. In this paper, we assume the latter to be the case, and that when a tax rate alters, the variation in the production scale of raw produce—a variation which is caused by the movement of capital and labour among sectors subject to the uniform profit principle—never brings in a less fertile land than the present marginal land, nor makes the cultivation regress to more fertile land. This assumption enables us to consider the input coefficients in equation (2) as constants even in the adjustment process.³

In the next section, we apply these presumptions and the basic model, and clarify by the method of comparative statics how a change in tax rates, t_2, t_3, t_r , and t_w , affects the uniform

¹ Each capitalist will calculate the value of g , which denotes the rate of increase in the price of his commodity, so as to satisfy the following equation

$$[(1 + g)(1 + r) - 1](1 - t_r) = r$$

The bracket on the left-hand side represents the rate of profits before tax by raising the price. The equation indicates that the rate of profits after tax, computed by multiplying the bracket by $(1 - t_r)$, has to be equal to the initial rate of profit for which each capitalist asked. We can acquire

$$g = rt_r / [(1 + r)(1 - t_r)]$$

from the above equation.

² Kuroki (1985) offers successful counter-evidence whereby capital movements do not always equalise rates of profit.

³ On the neo-Ricardian treatment of rent, see for instance Kurtz (1978) and Quadrio-Curzio (1980).

rate of profits and the relative prices satisfying equations (1), (2), and (3), which we denote r^* , p_2^* , and p_3^* .

3. Taxes on commodity flows

3.1 Tax on raw produce

Ricardo (1817, p. 160) argued that a tax on raw produce would raise the price of raw produce by the amount of the tax, and decrease the rate of profits throughout the economy due to the increase in the money wage. In our model, an increase in the rate of tax on raw produce, i.e. t_2 , influences the long-period values of the endogenous variables in the following manner

$$dp_2^*/dt_2 > 0 \tag{4}$$

$$dr^*/dt_2 < 0 \tag{5}$$

$$\frac{a_{23} + (1 + t_w)b_2l_3}{a_{13} + a_{23}p_2 + (1 + t_w)(b_1 + b_2p_2)l_3} \begin{matrix} \geq \\ \leq \end{matrix} \frac{a_{21} + (1 + t_w)b_2l_1}{a_{11} + a_{21}p_2 + (1 + t_w)(b_1 + b_2p_2)l_1} \Rightarrow dp_3^*/dt_2 \begin{matrix} \geq \\ \leq \end{matrix} 0 \tag{6}$$

The result in (4) indicates that an increase in the tax rate on raw produce raises the price of that commodity. However, contrary to Ricardo's reasoning, the incremental increase in the price does not always accord with the increase in the amount of the tax per unit of raw produce. His conclusion about the increase in the price of raw produce can be expressed in our notation as follows¹

$$dp_2^* = dt_2 p_2^*/(1 + t_2) \tag{7}$$

On the other hand, our model gives the following outcome

$$\frac{a_{22} + (1 + t_w)b_2l_2}{a_{12} + a_{22}p_2 + (1 + t_w)(b_1 + b_2p_2)l_2} \begin{matrix} \geq \\ \leq \end{matrix} \frac{a_{21} + (1 + t_w)b_2l_1}{a_{11} + a_{21}p_2 + (1 + t_w)(b_1 + b_2p_2)l_1} \Rightarrow dp_2^* \begin{matrix} \geq \\ \leq \end{matrix} dt_2 p_2^*/(1 + t_2) \tag{8}$$

Equation (8) states that, if a ratio of the input of raw produce (including consumption by labourers) to the total production cost is larger in the raw produce sector than in the numeraire (necessity) sector, the incremental increase in the price of raw produce exceeds the increase in the amount of the tax per unit of raw produce. What this outcome implies is that, when the production of raw produce requires the input of raw produce in a larger ratio to the total input than the production of numeraire commodity, the initial increase in the price of raw produce by the assessment raises the production cost of raw produce more extensively than it raises the production cost of the numeraire commodity. The consequence is that the relative price of raw produce rises beyond the amounts of the tax increase. On the same principle, the price of raw produce does not exceed the increase in the amount of the tax when it uses the input of raw produce in a smaller ratio than the numeraire commodity.

¹ $p_2^*/(1 + t_2)$ represents the sum excluding the amount of the tax. Ricardo determines the effects of taxation by comparing the situation with taxes to one without. We can easily make our model correspond to Ricardo's manner by rewriting t_2 to 0, and dt_2 to t_2 in (7) and (8). The essence of the subsequent discussion is not affected at all by this modification.

The reason why Ricardo's conclusion differs from ours is evident. He supposed that capitalists in the raw produce sector attempted to keep up the rate of profits by raising the price of that commodity, but the consequent rise in the money wage would reduce the rates of profit in all sectors by an identical amount. Our model takes explicitly into account the fact that the production of raw produce requires the input of itself, and an increase in its price raises the production cost and the production price in the other sectors, and these rises affect the cost and the price of raw produce. The extent of the incremental increase in the price of raw produce varies in a more complicated way than Ricardo supposed. Nevertheless, there is a special condition where his conclusion still holds true. That is the case in which the ratio of the input of raw produce to the total cost is identical between the raw produce and the numeraire sectors.

An increase in the rate of tax on raw produce might raise or reduce the price of luxuries, depending on the structure of production in the luxury and the numeraire sectors, a relationship delineated in (6). The implication in (6) is very similar to that in (8). That is because (6) states that the degrees of effects of a rise in the price of raw produce on the increase in the production cost in the luxury and the numeraire sectors depend on whether the production of luxuries uses raw produce in a larger ratio to the total cost than the production of the numeraire commodity or not. If the ratios are identical between these two sectors, the price of luxuries is not affected by the increase of tax on raw produce. We can state that the real purchasing power of landlords, who are the main consumers of luxuries in the Ricardian scheme, is influenced by the increase in the rate of tax on raw produce, depending on the cost structures of the sectors.¹

3.2 Tax on luxuries

Ricardo thought that a tax on luxuries would raise no more than the price of that commodity because labourers did not consume it (1817, pp. 243–244). He concluded that consumers of luxuries would exclusively bear the burden of the tax. Our model indicates the effects of an increase in the rate of tax on luxuries as follows

$$dp_2^*/dt_3 = 0 \quad (9)$$

$$dr^*/dt_3 = 0 \quad (10)$$

$$dp_3^*/dt_3 = p_3^*/(1 + t_3) > 0 \quad (11)$$

The above outcome depicts that an increase in t_3 brings no change in the price of raw produce and the uniform rate of profits, and raises the price of luxuries by just the increase in the amount of the tax per unit of luxuries. This result coincides completely with Ricardo's conclusion. It is obvious why the results of our model, which considers the reproduction structure, do not contradict Ricardo's statements on luxury taxes. We assumed in our model that luxuries are not inputs for the production of commodities nor consumed by labourers, so we created a price system in which the price of luxuries plays no role in determining the price of raw produce and the uniform rate of profits.²

4. Taxes on income flows

4.1 Tax on profits

According to Ricardo, a tax proportionate to profits imposed on all trades does not alter the relative prices of commodities although each capitalist in the economy attempts to shift

¹ Following the same procedure, we obtain the results that the increase in the rate of tax on necessities, i.e., t_1 , decreases the price of raw produce and luxuries, and reduces the uniform rate of profits.

² Sraffa (1960, p. 55) discusses how the tax on luxury (non-basic) goods affects their own prices, considering three types of non-basics.

the burden of the tax by raising the price of his commodity. The ultimate incidence of the tax is carried by all capitalists in the economy (Ricardo, 1817, pp. 205–206).

Our model entirely supports Ricardo's reasoning. An increase in the rate of tax on profits reduces the uniform rate of profits but does not affect the prices of raw produce and luxuries. That is

$$dp_2^*/dt_r = 0 \tag{12}$$

$$dr^*/dt_r < 0 \tag{13}$$

$$dp_3^*/dt_r = 0 \tag{14}$$

Ricardo (*ibid*, p. 205) argues that a tax levied on profits in a specific sector has the same price effect as a tax on the commodity in that sector. In our model, we can identify an increase in the tax on profits in a specific sector with the increase in t_1 , t_2 , or t_3 , whose effects on the relative prices and the uniform rate of profits we have already analysed.

4.2 Tax on wages

Ricardo accepted Malthus's principle of population, and did not believe that a tax on wages was paid by labourers. If the tax were imposed on the wage per worker equal to the subsistence level, the labour population would decrease and the price of labour would consequently rise. An increase in the money wage would bring about a reduction in the rate of profits through the trade-off relation between wages and profits. Capitalists, as a result, would have to pay the tax on wages instead of labourers.

Ricardo (1817, p. 215), who identified the tax on wages with the tax on profits, argued that the former no more changed the relative prices in the economy than the latter, while taxes on commodities consumed by labourers did change them.

Does the tax on wages really keep the relative prices unchanged as the tax on profits does? Our model indicates that an increase in the tax on wages affects the price system in the following way

$$\frac{a_{12} + a_{22}p_2}{l_2} \begin{matrix} \geq \\ < \end{matrix} \frac{a_{11} + a_{21}p_2}{l_1} \Rightarrow dp_2^*/dt_w \begin{matrix} \leq \\ \geq \end{matrix} 0 \tag{15}$$

$$dr^*/dt_w < 0 \tag{16}$$

$$\frac{a_{13} + a_{23}p_2}{l_3} \geq \frac{a_{12} + a_{22}p_2}{l_2} \geq \frac{a_{11} + a_{21}p_2}{l_1} \Rightarrow dp_3^*/dt_w \leq 0 \tag{17}$$

$$\frac{a_{13} + a_{23}p_2}{l_3} \leq \frac{a_{12} + a_{22}p_2}{l_2} \leq \frac{a_{11} + a_{21}p_2}{l_1} \Rightarrow dp_3^*/dt_w \geq 0$$

It is evident from the result in (16) that an increase in t_w reduces the uniform rate of profits. The result in (15) depicts that when a ratio of production means to labour (i.e. capital intensity) is larger in the raw produce sector than in the numeraire sector, an increase in the rate of tax on wages decreases the price of raw produce. This happens because the rate of the increase in the total cost caused by the increase in the labour cost is smaller in the production of raw produce than in that of numeraire commodity. Inversely, if the raw produce is produced with a smaller capital intensity than that of the numeraire commodity, the increase in the rate of tax on wages raises the relative price of raw produce. If the capital intensity is identical between the two sectors, then the price of raw produce never changes.

The result in (17) shows how the price of luxuries responds to an increase in the rate of tax on wages. If the capital intensity in the luxury sector is the highest (the lowest) in the three sectors, the price of luxuries decreases (increases) with an increase in tax on wages. If the capital intensity is identical among all the sectors, the price of luxuries does not vary. We can state nothing definite about the alternation in the price of luxuries in the case that satisfies neither of the conditions in (17).¹

We now indicate a sufficient condition in which an increase in tax on wages does not affect the relative price system; that is, an increase in tax on wages brings about the same effect as an increase in tax on profits. The condition is represented as follows

$$\frac{a_{11} + a_{21}p_2}{l_1} = \frac{a_{12} + a_{22}p_2}{l_2} = \frac{a_{13} + a_{23}p_2}{l_3} \quad (18)$$

This condition is what Ricardo assumed in order to obtain a relative price system never affected by any variation in the distribution between wages and profits. We can conclude that his explanation of the tax on wages is also valid in this special condition, i.e., in the case that all sectors have identical capital intensities.

4.2 Tax on rent

Ricardo believed that a tax proportionate to rent would fall entirely on landlords; he derived this from the theory of differential rent. Landlords cannot shift the burden of the tax to capitalists by raising their rent, because they can charge to capitalists only the difference in productivity between their lands and the marginal land where no rent is paid (Ricardo, 1817, p.173).

Ricardo thought that a land tax could be identified with a tax on rent if the former were levied in proportion to the rent of land. He continued, however, stating that if a land tax were imposed also on the rent of the marginal land, it would be a tax on produce, and would therefore raise the price of produce. According to Ricardo, this type of land tax does not differ from tithes and a tax on raw produce if it is proportional to the productivity of land, while the land tax has the same economic effect as a tax imposed solely on the profits of capitalists in the raw produce sector if it is a fixed tax per acre levied irrespective of the productivity of land (*ibid.*, p. 181).

Ricardo, moreover, argued that a land tax proportionate to the productivity of land, tithes, and a tax on raw produce would not change the money rent but instead reduce the corn rent, while a fixed land tax and a tax on profits in the raw produce sector would increase the money rent but leave the corn rent intact.²

Can we use our model to support such an argument? Let Q_i ($i = 1, 2, \dots, k$) be the output of raw produce on an acre of land of grade i with certain units of capital and labour. Q_k is the output per acre on the marginal land. We suppose $Q_j > Q_{j+1}$ ($j = 1, 2, \dots, k-1$). To simplify the subsequent discussion, let us suppose that no tax has been imposed so far on the sales of raw produce. When we denote the price of raw produce before introducing a tax by p_2^* , the money rent per acre in the land of grade i is

$$p_2^*(Q_i - Q_k) \quad (19)$$

¹ Pasinetti (1977, ch. 5) fully discusses the indeterminacy of the price effect caused by an alternation in wages or rates of profits.

² See Ricardo's numerical examples pertaining to this issue in Ricardo (1817, pp. 157–158, pp. 177–178, and pp. 211–212).

The corn rent, which is calculated by dividing the money rent by the price of raw produce, is expressed as

$$Q_i - Q_k \tag{20}$$

By applying the results in subsection 3.1, we make clear how the money rent and the corn rent shown in (19) and (20) will alter when we introduce the two types of taxes discussed above.

We first suppose that the amount of the tax per unit of raw produce, $t_2 p_2^*$, is now levied in the form of a land tax in proportion to the productivity of land, or a tax on raw produce. The introduction of the tax raises the price of raw produce. We denote the incremental increase in the price of raw produce with Δp_2^* . Then the proceeds before and after tax, and the money and the corn rent per acre in the land of grade i can be shown as follows:

$$\text{proceeds before tax: } (p_2^* + \Delta p_2^*)Q_i \tag{21}$$

$$\text{proceeds after tax: } (p_2^* + \Delta p_2^*)Q_i - t_2 p_2^* Q_i \tag{22}$$

$$\text{money rent: } (p_2^* + \Delta p_2^* - t_2 p_2^*)(Q_i - Q_k) \tag{23}$$

$$\text{corn rent: } \frac{(p_2^* + \Delta p_2^* - t_2 p_2^*)(Q_i - Q_k)}{p_2^* + \Delta p_2^*} \tag{24}$$

Can we tell that the land tax proportionate to the productivity of land and the tax on raw produce do not alter the money rent? It is evident from the outcome in (23) that the money rent is left intact when the next equation holds

$$\Delta p_2^* = t_2 p_2^* \tag{25}$$

Equation (25) is exactly what Ricardo supposed in arguing the price effect of the tax on raw produce, and it depicts fundamentally the same thing as equation (7) in subsection 3.1.¹ We can thereby conclude that the realisation of (25) depends on whether the reproduction structure in the economy satisfies the condition in (8).²

It is obvious that the corn rent represented in (24) is smaller than before, i.e. than $Q_i - Q_k$. Ricardo's statement that the land tax proportionate to the productivity of land and the tax on raw produce would reduce the corn rent remains valid even if an incremental increase in the price of raw produce does not satisfy equation (25).³

We next examine whether the fixed land tax levied irrespectively of the grade of land and the tax on profits in the raw produce sector will increase the money rent and maintain the

¹ When we consider not an increase in the existing tax but an introduction of tax, we can set $t_2 = 0$ and $dt_2 = t_2$ in (7) and (8). See p. 47, n. 1 above.

² Tithes do not submit to this result because they are paid in kind. The proceeds after tax in this case are denoted as

$$(p_2^* + \Delta p_2^*)Q_i - t_2(p_2^* + \Delta p_2^*)Q_i$$

The money rent becomes

$$(1 - t_2)(p_2^* + \Delta p_2^*)(Q_i - Q_k)$$

The condition by which the money rent is not affected by tithes is

$$\Delta p_2^* = t_2 p_2^* / (1 - t_2)$$

The corn rent is reduced from $Q_i - Q_k$ to $(1 - t_2)(Q_i - Q_k)$.

³ Eagly (1983) chose the price of raw produce as numeraire, so his model could not distinguish money rent from corn rent. As a result he drew the conclusion that the real purchasing power of rent would increase with the introduction of the tax on raw produce, a conclusion which apparently contradicts Ricardo's own statement.

corn rent unchanged. Suppose that producers of raw produce have to pay the tax of $p_2^* q$ per acre. q denotes the quantity of raw produce to be paid. The tax rate t_2 comes to q/Q_k in this case. When the price of raw produce rises from p_2^* to $p_2^* + \Delta p_2^*$, the proceeds before and after tax and the money and the corn rent per acre in the land of grade i become¹

$$\text{proceeds before tax: } (p_2^* + \Delta p_2^*)Q_i \quad (26)$$

$$\text{proceeds after tax: } (p_2^* + \Delta p_2^*)Q_i - p_2^* q \quad (27)$$

$$\text{money rent: } (p_2^* + \Delta p_2^*)(Q_i - Q_k) \quad (28)$$

$$\text{corn rent: } Q_i - Q_k \quad (29)$$

From the results in (28) and (29), we may state that the fixed land tax or the tax on profits in the raw produce sector increases the money rent but does not affect the corn rent. This outcome is summarily consistent with Ricardo's argument.

The above results bring out the situation which Ricardo called the curious circumstance where 'the landlord has a decided interest that his tenants' profits should be taxed' (1817, p. 213). Considering (8) and (23), we can add to it another curious circumstance where the landlord has a decided interest that the production in his sector needs more input of raw produce than in the numeraire sector.

5. Conclusion

We may conclude from the analysis in the preceding sections that many outcomes derived from our model considering the reproduction system are consistent with Ricardo's own argument. Our model, however, brings about different outcomes from his concerning the issues of whether or not (i) the tax on raw produce raises the price of that commodity to the extent of the amount of the tax, (ii) the tax on raw produce affects the price of luxuries, (iii) the tax on wages changes the relative prices in the economy, and (iv) the land tax proportionate to the productivity of land or the tax on raw produce keeps the money rent unchanged. We can obtain from (6), (8), and (18) the sufficient condition as follows in which Ricardo's conclusion coincides with our results about these four problems

$$\frac{a_{11}}{l_1} = \frac{a_{12}}{l_2} = \frac{a_{13}}{l_3} \text{ and } \frac{a_{21}}{l_1} = \frac{a_{22}}{l_2} = \frac{a_{23}}{l_3} \quad (30)$$

This condition is very strict. It indeed demands more than a uniform capital intensity among sectors. It implies that a labourer in any sector works with homogenous units of composite factors. However, if we acknowledge Ricardo's clear declaration of a labour proportionality rule in his *Principles* (1817, pp. 36–37), we have to stress that his conclusions on tax incidence are strictly speaking correct.

Moreover, Ricardo's main assertion that any tax except those on rent and luxuries will ultimately reduce profits is not affected at all by our results. Ricardo devoted many chapters in his *Principles* to the issue of tax incidence with a negative attitude toward taxation from the viewpoint of economic development. He discloses his fundamental interpretation of taxation as follows in Chapter VIII of *Principles*, entitled 'On Taxes':

¹ Ricardo's numerical example presupposes a tax in kind. In that case, the money amount of tax becomes $(p_2^* + \Delta p_2^*)q$ not $p_2^* q$. This modification, however, never influences the result in (28) and (29). Considering note 2, p. 31, we can draw an interesting conclusion: in the case of a tax proportionate to the productivity of land, the money and the corn rent are affected by whether capitalists must pay as a fixed amount of money or as a fixed quantity of their product per unit of the product. In the case of a fixed tax, the money and the corn rent are never affected by the means of payment.

Notwithstanding the immense expenditure of the English government during the last twenty years, there can be little doubt that the increased production on the part of the people has more than compensated for it. . . .

Still, however, it is certain that but for taxation this increase of capital would have been much greater. There are no taxes which have not a tendency to lessen the power to accumulate. All taxes must either fall on capital or revenue. If they encroach on capital, they must proportionably diminish that fund by whose extent the extent of the productive industry of the country must always be regulated; and if they fall on revenue, they must either lessen accumulation, or force the contributors to save the amount of the tax, by making a corresponding diminution of their former unproductive consumption of the necessaries and luxuries of life. Some taxes will produce these effects in a much greater degree than others; but the great evil of taxation is to be found, not so much in any selection of its objects, as in the general amount of its effects taken collectively (*ibid.*, pp. 151–152).

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