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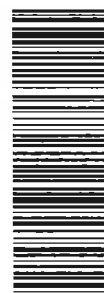
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The Ricardo Effect: Its Meaning and Validity

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This paper is concerned with the meaning and validity of the 'Ricardo effect'. It is shown that the machinery substitution effect contemplated by David Ricardo (a) is not caused by a rise in the real wage rate, (b) is independent of the so-called 'price effect', and (c) presupposes very special assumptions about the available set of production methods. The paper also investigates whether Ricardo's machinery substitution argument anticipates the principle of factor substitution with regard to capital and labour in marginalist theory.

INTRODUCTION

The term 'Ricardo effect' was introduced by Friedrich A. Hayek in *Profits, Interest and Investment* for 'the familiar Ricardian proposition that a rise in wages will encourage capitalists to substitute machinery for labour and *vice versa*' (Hayek 1939, p. 8). Hayek's notion was immediately criticized by Nicholas Kaldor on the ground that 'the proposition of Ricardo and that attributed to him by Professor Hayek are not the same—the assumptions are different, the mode of operation is different, and the conditions of validity are quite different ...; whatever the truth in [Hayek's] argument ..., it is certainly not Ricardo's. The term "Ricardo effect" is clearly a misnomer' (Kaldor 1942, pp. 364 and 367). Mark Blaug also suggested that 'the Ricardo Effect is really a misnomer' ([1962] 1997, p. 544), and C. E. Ferguson maintained: 'The so-called Ricardo effect never appeared in the works of Ricardo. It was the invention of Hayek' (Ferguson 1973, p. 6).

Hayek's notion was defended, however, by O'Driscoll, who claimed that 'Hayek used the effect exactly as Ricardo had' (1977, p. 121), and by Moss and Vaughn, who identified 'two uses of the Ricardo effect in Ricardo's *Principles*, each of which bears a certain similarity to the mechanism Hayek finally developed' (1986, p. 547). Zamagni also maintained that Hayek was justified in attributing the proposition under consideration to Ricardo, and indeed suggested calling it the 'Ricardo–Hayek effect' (1987, p. 198). More recently, the issue was studied by Perri (1988), Meacci (1994) and Hagemann and Trautwein (1998). However, almost six decades after its first inception, the meaning and validity of Hayek's 'Ricardo effect', and in particular its relation to the argument originally put forward by Ricardo, is still controversial. The purpose of this paper is to contribute to the clarification of this matter. It should be made clear at the outset, however, that no attempt will be made to assess the validity of Hayek's argument in his own theory of industrial fluctuations. The aim is merely 'to clear up a matter of *Dogmengeschichte*; the relation of Ricardo to what Professor Hayek calls the "Ricardo effect"' (Kaldor 1942, p. 364).

The paper is organized as follows. In Section I Hayek's statement of the 'Ricardo effect' is briefly recalled. In Section II the passages in Ricardo's *Principles* in which he allegedly formulated the effect under consideration are

scrutinized and the conditions for Ricardo's proposition to be valid are studied. Section III clarifies the role of Ricardo's machinery substitution argument in the emergence of the neoclassical principle of factor substitution with regard to capital and labour, and Section IV summarizes.

I. HAYEK'S 'RICARDO EFFECT'

Hayek first adopted the term 'Ricardo effect' in *Profits, Interest and Investment* (1939) as a shorthand expression for the proposition that a rise in wages will encourage capitalists to substitute machinery for labour. However, as he was later to explain, he had made use of this effect (though not of the name) in his earlier contributions to trade cycle theory, and in particular in *Prices and Production* (1931),¹ and had adopted this name only, 'because J. A. Schumpeter (1939, pp. 345, 812, 814) had referred to a more general and even less original aspect of my theory as the "Hayek Effect", and I did not wish what I regarded as an old-established doctrine to be regarded as an innovation' (Hayek 1969, p. 274).² In subsequent contributions Hayek then made ample use of the new notion. In 'The Ricardo Effect' of 1942, he summarized his proposition thus:

The proposition here described as the Ricardo Effect asserts that a general change in wages relatively to the prices of the products will alter the relative profitability of different industries or methods of production which employ labour and capital ('indirect labour') in different proportions. In its original form it asserts that a general rise in wages relatively to the prices of the products will reduce the profitability of the industries or methods employing relatively more capital to a lesser extent than those employing relatively less capital. (Hayek 1942, p. 129)

However, it is not the 'original' but rather the 'reverse' form of this proposition that plays a central role in Hayek's trade cycle theory. According to Hayek, the boom phase of the trade cycle typically exhibits rising prices of consumer goods not matched by proportionate increases in nominal wages, so that real wages fall. This in turn is taken to raise the (expected) profitability of industries or production methods employing relatively less capital, or capital that is relatively less durable, to a greater extent than those for which the reverse holds. The fall in the real wage rate therefore triggers two opposing tendencies with regard to the aggregate demand for investment: on the one hand, the propensity to invest is increased because of the enhanced (expected) profitability, while on the other hand producers are encouraged to employ production methods that are relatively more labour-intensive. According to Hayek, the latter effect must outbalance the former, so that the aggregate demand for investment goods must fall. The 'Ricardo effect' is thus taken to hold the key to the explanation of a phenomenon to which Hayek attached great importance. He argued that the Keynesian 'acceleration principle of derived demand' is transformed into a 'deceleration principle' under the typical boom conditions of full employment and full capacity utilization (Hayek 1941, p. 387). In his article 'Three elucidations of the Ricardo effect', published nearly thirty years later in response to Hicks (1967), Hayek even declared that this 'deceleration effect' captures the main point of his argument:

The Theorem called the Ricardo Effect asserts that in conditions of full employment an increase in the demand for consumer goods will produce a decrease of investment, and *vice versa*. (Hayek 1969, p. 274)

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However, this is of course not the proposition that Hayek meant to attribute to Ricardo. It is rather the intermediate step in his argument, according to which a fall in the level of real wages will increase the profitability of those industries or production methods that use relatively less 'indirect' and relatively more 'direct' labour, so that producers are induced to switch 'from more to less capital-intensive methods' and to make use of 'less labor-saving or less durable equipment than before' (Hayek 1969, p. 277).

II. RICARDO'S 'MACHINERY SUBSTITUTION EFFECT'

For Ricardo's exposition of the 'Ricardo effect', Hayek (1939, p. 8, and 1942, p. 127) referred his readers to two passages in the *Principles* (henceforth *Works*), the first of which is contained in Section V of Chapter I, 'On Value' (*Works* I, pp. 40–1), the second in Chapter 31, 'On Machinery' (*Works* I, p. 365).

The machinery substitution effect in the chapter 'On Value'

In Sections IV and V of Chapter I of the *Principles*, Ricardo demonstrated, by means of simple numerical examples, that a change in distribution must affect the prices of commodities produced with different proportions of fixed and circulating capital (Section IV), or with fixed capitals of different durability (Section V), differently. Section V opens with the statement:

Every rise of wages, ... or, which is the same thing, every fall of profits, would lower the relative value of those commodities which were produced with a capital of a durable nature, and would proportionally elevate those which were produced with capital more perishable. A fall of wages would have precisely the contrary effect. (*Works* I, pp. 39–40)

This statement refers to the effects of changes in the level of *real* wages (or inverse changes in the level of the rate of profits) on the *relative* prices of commodities that are produced with capitals of different durability. Ricardo then presented a numerical example from which he derived the proposition that, 'with every rise in the price of labour, new temptations are offered to the use of machinery' (*Works* I, p. 41). It is this numerical example on which Hayek's attribution of the 'Ricardo effect' to Ricardo is mainly based.

Before we scrutinize Ricardo's arithmetical example, it is useful to introduce some definitions. In what follows, Ricardo's proposition that a rise in *real* wages (or a fall in the general rate of profits) will lead to a fall in the *relative* prices of those commodities that are produced with a large proportion of fixed capital, or with fixed capital of great durability, will be called the 'price effect', while the proposition that every rise of wages will offer new temptations to the use of machinery will be called the 'machinery substitution effect'.

Several commentators have maintained that the 'machinery substitution effect' is caused by the 'price effect', and that, accordingly, for Ricardo's argument to be valid, the (implicit) assumption that machines are produced with a relatively large proportion of fixed capital, or with fixed capital of great durability, is required.³ Moreover, some authors (including, as we saw above, Hayek) interpreted Ricardo as having assumed a rise in the *real* wage rate to begin with for the machinery substitution effect to occur.

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The following reconstruction of Ricardo's argument will show that the 'machinery substitution effect' contemplated by Ricardo (1) is *not* caused by a rise in the *real* wage rate; (2) is *independent of the 'price effect'* (which implies, of course, that Ricardo had no need to make any assumptions whatsoever about the relative 'capital-intensiveness' of the machine goods industry); and (3) is based on very *special assumptions* about the available set of production methods from which producers can choose, and thus is *not of general validity*.

Ricardo's example

Ricardo illustrated his substitution argument with the following numerical example (cf. *Works* I, pp. 40–2). Suppose a manufacturer employs 100 men for a year at a money wage of £50 each. Suppose further that a machine that lasts for a year and can do exactly the same work as the 100 men could be purchased for £5000. Then 'it is evident that it would be a matter of indifference to the manufacturer whether he bought the machine or employed the men' (*Works* I, p. 40). Yet with a higher money wage rate this is no longer the case:

But suppose labour to rise, and consequently the wages of one hundred men for a year to amount to 5,500*l.*, it is obvious that the manufacturer would now no longer hesitate, it would be for his interest to buy the machine and get his work done for 5000*l.* (*Works* I, p. 40)

It could be objected, Ricardo continued, that the price of the machine would also rise proportionally, since the maker of the machine must also pay higher money wages. Yet this is not the case, because the former price of the machine could have covered the machine maker's expenses plus normal profits only if fewer than 100 men had been employed in its construction. Suppose, then, that the machine was produced by 85 men in the course of a year, so that the capital advanced by the producer of the machine before the rise in money wages amounted to £4250 (and his profit, accordingly, to £750). The rise in the annual money wage per worker (from £50 to £55) would not raise the wage costs of the machine maker by the same amount as the costs of direct labour. If he nevertheless raised the price of his machine by 10%, he would pocket extra profits—which, however, would immediately attract additional capital to his trade:

If therefore the maker of the machine should raise the price of it in consequence of a rise of wages, an unusual quantity of capital would be employed in the construction of such machines, till their price afforded only the common rate of profits. (*Works* I, p. 41)

According to Ricardo, in conditions of universal free competition the maker of the machine would not be able to raise the money price of his product at all, and would be obliged to continue to sell it at the former price of £5000—which means, of course, that the profitability of his capital has been reduced. But this is 'precisely the case of all manufacturers and capitalists; the rise of wages affects them all' (*Works* I, p. 41). The general rise in money wages contemplated by Ricardo is associated with a fall in the *general rate of profits*, and since the 'machines would not rise in price, in consequence of a rise of wages' (*Works* I, p. 41), the manufacturer would now no longer hesitate to substitute the machine for the workers. However, any manufacturer who can

still purchase a machine for £5000, and still sell his commodities at their former price, would obviously obtain the same rate of profits as he had before the increase in money wages; that is, in the new conditions he would earn a higher rate of profits than the capitalists in other branches. In competitive conditions the manufacturer would therefore be obliged 'to lower the price of his commodities, or capital would flow to this trade till his profits had sunk to the general level' (*Works* I, pp. 41–2). Consequently, the money prices of the commodities produced with the aid of the newly introduced machine must fall:

Thus then is the public benefited by machinery: these mute agents are always the produce of much less labour than that which they displace, even when they are of the same money value. Through their influence, *an increase in the price of provisions which raises wages* will affect fewer persons, it will reach, as in the above instance, eighty-five men instead of a hundred, and the saving which is the consequence, shows itself in the reduced price of the commodity manufactured. (*Works* I, p. 42; emphasis added)

Ricardo's substitution argument is thus seen to be based on the assumption that the rise in *money wages* which causes the substitution of machinery for labour is itself the consequence of 'an increase in the price of provisions'. And the latter in turn is taken to arise from 'increasing difficulties' encountered in the supply of provisions, i.e. in agricultural production, as is made clear in a note that Ricardo attached to the above statement:

We here see why it is that old countries are constantly impelled to employ machinery, and new countries to employ labour. *With every difficulty of providing for the maintenance of men, labour necessarily rises*, and with every rise in the price of labour, new temptations are offered to the use of machinery. This difficulty of providing for the maintenance of men is in constant operation in old countries, in new ones a very great increase in the population may take place without the least rise in the wages of labour. (*Works* I, p. 41; emphasis added)

The machinery substitution effect in the chapter 'On Machinery'

The second passage Hayek referred to is contained in Chapter 31, 'On Machinery'. It reads:

With every increase of capital and population, food will generally rise, on account of its being more difficult to produce. The consequence of a rise of food will be a rise of wages, and every rise of wages will have a tendency to determine the saved capital in a greater proportion than before to the employment of machinery. Machinery and labour are in constant competition, and the former can frequently not be employed until labour rises. (*Works* I, p. 395)

With the accumulation of capital and the growth in population the country must have recourse to less fertile land (or to a more intensive use of the land already under cultivation). In agriculture the amount of labour per unit of output rises (on the marginal land), and therefore agricultural products rise in price relative to the products of manufacturers. To keep the real wage rate constant, the *money* wage must be raised in order to compensate for the increase in the price of provisions. While agricultural production exhibits increasing costs, manufacturing is characterized by approximately constant costs. This implies: 'The *same* cause that raises labour [i.e. money wages] does not raise the value of machines, and, therefore, with every augmentation of

capital, a greater proportion of it is employed in machinery' (*Works* I, p. 395; emphasis added).

Ricardo's argument can be illustrated by means of the wage-profit frontiers depicted in Figure 1 (see Jeck and Kurz 1983, pp. 160–4; and Kurz 1998, p. 128). In the purely hypothetical case in which capital accumulation proceeds without any improvements in the methods of production the wage-profit frontier would gradually shift towards the origin owing to diminishing returns in agriculture and the related rise in the rent of land. In Figure 1 the two wage-profit frontiers T_0 and T_1 refer to this hypothetical course of events. While T_0 refers to an early stage of economic development, T_1 refers to a later one, on the premiss that no improvements have taken place. Clearly, with a given and constant real wage rate w' , the general rate of profits would fall from r_0 to r'_1 when output is increased in order to supply the required amounts of food. (The money wage must of course rise in order to counterbalance the associated rise in the prices of the wage goods.) Suppose now that the wage-profit frontiers shift from T_0 to M_0 , and from T_1 to M_1 , if in the manufacturing sector the machine were employed instead of direct labour. With a relatively low money wage rate (£50 in Ricardo's example), the manufacturer is indifferent between the two methods: at the going real wage rate w' the employment of the machine and that of direct labour gives the same rate of profits r_0 . However, with a higher money wage rate (£55) it would be more profitable for the manufacturer to use the machine, since M_1 is associated with a higher rate of profits, at the going real wage rate w' , than T_1 : $r_1^M > r_1^T$.

Figure 1 can also be used to illustrate Ricardo's statement that 'machinery can frequently not be employed until labour rises'. Supposing the common real

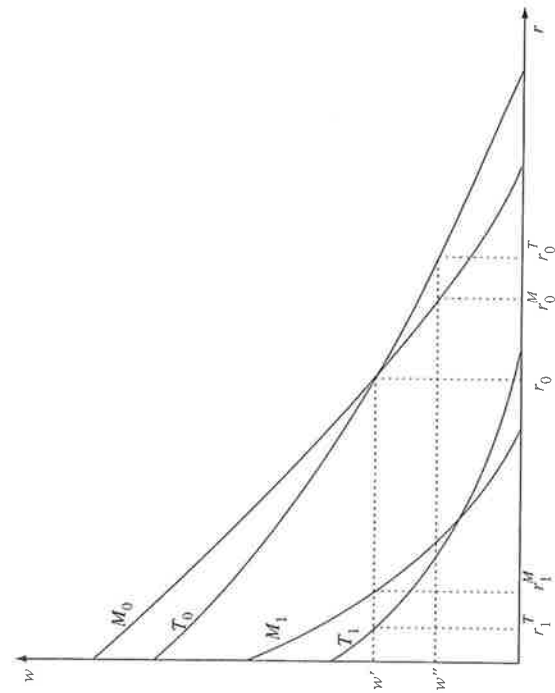


FIGURE 1. Ricardo's machinery substitution argument

wage rate to be fixed at w'' , it would not pay to introduce the machine in the early stage of development, while in the more advanced stage, with its associated higher money wage rate, it would be profitable to do so. The 'machinery substitution argument' of Chapter 31 is precisely the same argument as the one presented in Chapter 1. In both cases Ricardo refers to the solutions to a choice of technique problem on the basis of a comparative-static analysis of long-period positions associated with different levels of agricultural output (and, hence, with different levels of the prices of agricultural commodities and money wages). The interpretation of Moss and Vaughn (1986, p. 550), according to which Chapter 31 contains a dynamic version of 'Ricardo's Ricardo effect', which differs from the comparative-static exercise presented in Chapter 1, cannot be sustained.

The validity of Ricardo's 'machinery substitution argument'

We can now examine the question of the conditions for the validity of Ricardo's substitution argument. It is easily recognized that the 'machinery substitution effect' does not depend on the 'price effect'. Ricardo assumes that the machine can substitute a certain amount of direct labour (L_d) in some particular branch of the manufacturing sector, and that its money price (p_m) equals the money value of the wage capital expended on direct labour at the money wage ω_0 ; that is,

$$(1) \quad \omega_0 L_d = p_m = \omega_0 L_m(1 + r_0),$$

where L_m denotes the amount of labour embodied in the machine. Following Ricardo, the machine is assumed to be produced 'by unassisted labour in the course of a year'. Note that Ricardo does not specify the amounts of the material inputs that are employed together with the men or the machine. He thus appears to suppose that either no material inputs are required at all, or that in both cases precisely the same material inputs are required at the same amounts are required. If the money wage rate now rises from ω_0 to ω_1 (and the general rate of profits falls from r_0 to r_1), it must obviously be true that

$$(2) \quad \omega_1 L_d > \omega_1 L_m(1 + r_1),$$

since the amount of labour embodied in the machine must necessarily be smaller, with a positive rate of profits, than the amount of direct labour displaced by it. With a rise in the money wage rate, and the associated fall in the general rate of profits, the price of the machine must therefore always fall relative to the price of labour. This statement holds true whatever the 'capital intensity' of the machine relative to that of other commodities might be: Ricardo's 'machinery substitution effect' is thus independent of the 'price effect' (see also Perri 1988, p. 514).⁴

Interestingly, this was clearly understood already by the Cambridge philosopher and mathematician William Whewell ([1831] 1971), who reformulated Ricardo's numerical example in Section V of Chapter 1 as a choice of technique problem employing the concept of the 'reduction to dated quantities of labour'. Whewell approached the choice of technique problem by

formulating inequalities, and thus by making use of the concept of 'extra costs' (or 'extra profits').⁵

Let a machine have been produced by the labour of l' labourers last year, l'' in the preceding year, l''' in the year before that, and so on. And let l men be employed in working the machine; then its produce must be worth

$$(1+r)\omega + (1+r)^2 l' \omega + (1+r)^3 l'' \omega + \&c.$$

Let L be the number of men requisite to obtain the same produce without the machine. Then $L\omega$ is their wages, and $(1+r)L\omega$ the value of the produce. Therefore, if the machine can be employed without loss

$$(1+r)\omega + (1+r)^2 l' \omega + (1+r)^3 l'' \omega + \&c. = \text{or} < (1+r)L\omega,$$

$$\text{and } l + (1+r)l' + (1+r)^2 l'' + \&c. = \text{or} < L.$$

$$\text{Hence } l + l' + l'' + \&c. < L;$$

or, when machinery is employed, it has always cost less labour than would obtain the same produce without machinery. (Whewell [1831] 1971, p. 20)

Ricardo's machinery substitution argument was also endorsed by Karl Marx. In Chapter 13 of Volume I of *Capital*, Marx quoted approvingly Ricardo's proposition that 'these mute agents [the machines] are always the produce of much less labour than that which they displace, even when they are of the same money value', and stressed his agreement with Ricardo's conclusion that 'machinery ... can frequently not be employed until labour [he means the wage] rises' (Marx [1867] 1954, pp. 392 and 393; Marx's insertions). And in *Theories of Surplus Value*, Marx actually reproduced the numerical example in Section V of Chapter I of the *Principles* in full length, and remarked: 'This point is quite right' (Marx [1861–3] 1975, p. 178).

As we have seen above, Marx's approval of 'this point' is justified: Ricardo's proposition that, with a rise in the money wage rate (and a fall in the general rate of profits), the price of machines must always fall *relative* to the price of labour is correct—whatever the production conditions of machines may be. But what justifies Ricardo's assertion that the increase in money wages must leave the *absolute* price of the machine, i.e. its price in terms of money, unaltered?

Ricardo considered gold (or money) to be an invariable measure of value which is always produced by means of the same quantity of (direct and indirect) labour per ounce. In the first edition of the *Principles* (1987), he assumed gold to be produced by 'unassisted labour for a year', which implied that '... commodities may be lowered in value in consequence of a real rise of wages, but they never can be raised from that cause' (the reason being that in the production of some commodities fixed capital enters while it does not enter into the production of gold or money) (Staffa 1951, pp. xlii–xliii). Since Ricardo supposed the machine to be also produced by 'unassisted labour for a year', he could indeed correctly claim that its *money* price would not be altered. And he could correctly maintain that

Neither machines nor any other commodities are raised in price, but all commodities which are made by machines fall, and fall in proportion to their durability. (*Works* I, p. 62; emphases added)

In the third edition (1821), however, Ricardo assumed that the production conditions of gold are 'so nearly equally distant from the two extremes, the one

where little fixed capital is used, the other where little labour is employed, as to form a just mean between them' (*Works* I, pp. 45–6). This change in the production conditions of the commodity that serves as the standard of value implied that the price of a machine, expressed in terms of this standard, could fall, rise or remain constant with a rise in wages (and the associated fall in the rate of profits), depending on whether the machine is produced with above-average, below-average or average proportions of fixed and circulating capital. If the machine were produced by means of 'unassisted labour for a year', as Ricardo assumed, its money price could remain unaltered only if gold (or money) were supposed to be produced under precisely the same conditions. But this would imply, since gold was at the same time supposed to form 'a just mean between the extremes', that *all* commodities must be assumed to be produced by means of 'unassisted labour for a year'.

Ricardo was aware that his new standard necessitated modifications in his propositions about the changes in absolute prices induced by distributional changes. Indeed, in the third edition he altered the statement of the first edition that was cited above in the following way:

Neither machines, nor the commodities made by them, rise in real value, but all commodities made by machines fall, and fall in proportion to their durability. (*Works* I, p. 42; emphases added)

He thus acknowledged that with the new standard some commodities might rise in 'real value', but denied that machines, or the commodities made by them, could do so. The rationale behind this proposition is the idea that, if gold or money were a perfect measure of the 'real' or 'absolute value' of commodities, then a reduction (increase) in the amount of labour needed to produce any commodity should be reflected in a proportional reduction (increase) in its money price, while the prices of commodities that require the same amount of labour as before should remain unchanged. However, the same cause that prompted him to acknowledge that some commodities might rise in 'real value' with a rise in wages, even if the amount of labour required to produce them had not changed, applies to machines no less than to other commodities: if the latter are produced with proportions of fixed and circulating capital that are different from those of the standard, then they too can rise or fall in 'real value' in spite of an unchanged amount of labour required to produce them. Ricardo's proposition therefore cannot in general be sustained. With the third edition standard it cannot be excluded that the *absolute* value of machines, that is, their price in terms of gold, might rise with an increase in money wages (and the associated fall in the rate of profits).

The *relative* price of machines is, of course, independent of the standard of value. While machines, as we have seen, must always fall relative to the value of labour, their relative value compared with other commodities can rise, fall or remain constant. Obviously, this is also the case with regard to a commodity that enters into the wage basket. What, then, about the wage basket as a whole? Could the machine perhaps also rise in price *relative* to *all* commodities entering the wage basket? Put differently, could the 'price effect' perhaps make the commodity basket consumed by the workers cheaper relative to the machine? Apparently not, for in this case the money wage would not have to rise in order to keep the real wage rate constant. Hence, whenever the money

wage must rise in order to compensate for the increased prices of agricultural products entering the wage basket, machines must always fall in price relative to the wage basket.⁶

This then raises the question of whether Ricardo's principle that 'with every rise in the price of labour, new temptations are offered to the use of machinery' (*Works* I, p. 41) is indeed generally valid. To see that it is not, it suffices to note that Ricardo contemplates an *extremely special case* when comparing two methods of production for a commodity that differ from each other only in that one of them uses a certain amount of direct labour together with some material inputs, while the other one uses a certain amount of indirect labour (in the form of a machine) *together with exactly the same material inputs in exactly the same amounts*. (The alternative interpretation of Ricardo's reasoning, according to which he assumes that both methods require no material inputs at all (apart from the machine), is obviously no less special.) It is reasonable to suppose that a substitution of machinery for labour will in general be associated with changes in the type and/or the amounts of material inputs that are employed together with the workers (and the machine). If this is the case, however, there is no longer any reason to suppose that the machine-using method must generally become more profitable, relative to the one that uses direct labour, with a rise in money wages (and the associated fall in the general rate of profits). The reason for this is that Ricardo's view, according to which 'every rise of wages, ... or, which is the same thing, every fall of profits, would lower the relative value of those commodities which were produced with a capital of a durable nature, and would proportionately elevate those which were produced with capital more perishable' (*Works* I, p. 39), is not generally true. For the changes in the price relation of two commodities induced by a change in wages depend not only on the 'proportions' between labour and means of production by means of which these commodities are themselves produced, but also on the 'proportions' in which labour and means of production enter into the production of those means of production, and into the means of production of those means of production, and so on:

The result is that the relative prices of two products may move in the opposite direction to what we might have expected on the basis of their respective 'proportions'. (Sraffa 1960, p. 15)

For this reason it cannot be ruled out that, with a rise in the money wage rate and a fall in the general rate of profits (at an unchanged real wage rate), cost-minimizing producers can be induced to switch to a method that, at a lower level of the money wage rate (and a higher level of the general rate of profits), would have seemed less 'capital-intensive' than the method that they would have adopted then.

III. RICARDO'S 'MACHINERY SUBSTITUTION EFFECT' AND THE NEOCLASSICAL PRINCIPLE OF FACTOR SUBSTITUTION WITH REGARD TO CAPITAL AND LABOUR

In this section we will attempt to clarify the relationship between Ricardo's machinery substitution argument and the principle of factor substitution with regard to capital and labour in the traditional marginalist theory, and in

particular in the Austrian variant of the latter. In doing so, we will also draw attention to an element in the emergence of the marginalist approach to economic theory that seems to have been little recognized.

Let us briefly recall the basic features of the principle of factor substitution with regard to capital and labour in the traditional marginalist theory, as it was elaborated by authors such as Jevons, Böhm-Bawerk and Wicksell. In a nutshell, the principle supposes that, given a number of alternative 'techniques' for the 'integrated' production of a commodity by means of labour and capital goods, the techniques can be ordered according to their 'capital intensity'. The theory then asserted that any change of technique as the rate of interest falls will be in favour of the more capital-intensive one. When this assertion was shown to be false, with the demonstration of the possibilities of 'reswitching' and 'capital reversing', it seemed natural to ask 'how that fallacy came to be accepted into the body of economic theory' (Garegnani 1966, p. 562). In answer, it was suggested that the proposition under consideration had resulted from the attempt to apply the theory of intensive rent, which the classical writers had restricted to land and other non-reproducible inputs, to all factors of production, including a factor called 'capital':

The above proposition about changes in capital intensity has resulted from the attempt to apply to 'capital' and labor (or, more generally, 'capital' and other factors) a principle which was first formulated for factors like labor and land. (Garegnani 1966, p. 562)

It was thus suggested that the proposition of a monotonic inverse relationship between the level of the rate of interest and the 'capital intensity' of the cost-minimizing technique had been introduced into the body of economic theory only with the advent of the marginalist approach to economic theory.

In order to find out whether Ricardo's 'machinery substitution effect' might perhaps also have played a role in the emergence of this proposition, it seems appropriate to check whether the early marginalist writers saw any connection between Ricardo's substitution argument and their own. As is well known, the most careful formulation of the traditional marginalist theory of capital and interest was provided by Böhm-Bawerk and Wicksell, who elaborated on Jevons's contribution. If, then, we focus attention on the Jevons–Böhm-Bawerk–Wicksell line in the development of the marginalist approach, then neither Jevons nor Böhm-Bawerk seem to acknowledge any role for Ricardo's machinery substitution argument in the development of their ideas.⁷ Knut Wicksell, however, strongly emphasized the close relationship between Ricardo's machinery substitution argument and the marginalist factor substitution principle. In *Value, Capital, and Rent* he observed, commenting on the numerical example in Section V of Chapter I of Ricardo's *Principles*:

Here, too, Ricardo has correctly understood the sequence of cause and effect: if money wages rise (which in his view could only happen over longer periods as a result of the greater difficulty in producing the means of maintenance of workers, although in general such a rise can be understood as the consequence of every increase of capital), then the introduction of machines which before proved unproductive will now become more profitable, as he has shown in an ingenious example. The price of machinery, that is to say, includes profit as well as wages. As

this profit, like all the others, must fall when wages rise, the price of machines can consequently never rise in the same proportion as wages. (Wicksell [1893] 1954, p. 37)

Wicksell then goes on to suggest that, 'according to the more modern terminology, this means that every increase of wages encourages a lengthening of the period of production' (Wicksell [1893] 1954, pp. 37–8). The same interpretation of Ricardo's machinery substitution effect was put forward in *Finanztheoretische Untersuchungen* (1896, p. 27)⁸ and in Volume I of Wicksell's *Lectures*, where Ricardo's machinery analysis is said to contain, 'in a somewhat different form, one of the corner stones of Böhm-Bawerk's own theory' ([1901] 1934, p. 167). According to Wicksell, the argument put forward by Ricardo is 'fundamentally the same reasoning as that with which Böhm-Bawerk proves ... that a rise in wages must lead to a lengthening of the period of production or of capital investment' ([1901] 1934, p. 168). It would seem, then, that 'one of the corner stones' of the marginalist theory of capital and interest can indeed be traced back to Ricardo (and was fully endorsed Marx).

One author—Victor Edelberg—even maintained that Wicksell had conclusively demonstrated that Ricardo's machinery substitution argument is an early formulation of the principle of diminishing marginal productivity with regard to the factor 'capital'. He claimed, allegedly following Wicksell's interpretation, that Ricardo's machinery substitution argument could be summarized thus:

Ricardo states that if the market rate of interest falls, it becomes profitable to work a two-year process where only a one-year process was profitable before ... the example shows that as the period of production lengthens ... the output increases, the marginal productivity rate of interest falls, and real wages rise. (Edelberg 1933, pp. 62–3)

It is easily recognized that Edelberg has introduced a causality that is contained neither in Ricardo's numerical example nor in Wicksell's interpretation of the latter. Ricardo had conceived of the 'lengthening of the period of production' (that is, of the substitution of machinery for labour) not as the cause, but rather as the *effect*, of the fall in the general rate of profits. The latter was taken to result not from the 'diminishing marginal productivity of capital', but rather from the 'increasing difficulties' that are encountered in the production of wage goods. Wicksell was perfectly aware of this different causality, and he therefore never went so far as to suggest that Ricardo had anticipated the marginal productivity theory of capital:

Since, according to Ricardo, wages represent a magnitude fixed from the beginning, ..., the cause of capital profit is already settled. It is neither possible nor necessary to explain capital profit in other ways. (Wicksell [1893] 1954, p. 37)

That Ricardo's determination of the rate of profits was based on the surplus approach, with the real wage rate treated as given, was also pointed out by Wicksell in his *Lectures*, where he added: 'Ricardo's theory of interest ... appears to be quite correct so far as it goes' ([1901] 1934, p. 167). In Wicksell's view, the main objection to Ricardo's theory is that the level of real wages is taken to be determined independently of, and *prior to*, the determination of the general rate of profit (cf. Wicksell [1893] 1954, pp. 145–6). And it is indeed precisely for this reason that Ricardo's 'machinery substitution effect' cannot

be considered as an early formulation of the marginalist factor substitution principle. In Ricardo's argument, unlike in the marginalist approach, the 'factor prices' of capital and labour—the rate of profits and the real wage rate—are not determined symmetrically and simultaneously with the factor input proportions: rather, they are treated asymmetrically. In the analysis of the problem of the choice of technique and the determination of the general rate of profits, Ricardo takes the real wage rate as given.

IV. CONCLUSION

In this paper it has been shown that the 'machinery substitution effect' contemplated by David Ricardo in Chapters 1 and 31 of the *Principles* (1) is caused not by a rise in the real wage rate but rather by a rise in the money wage rate; and (2) is independent of the so-called 'price effect' (which implies that Ricardo had no need to make any assumptions whatsoever about the relative 'capital-intensiveness' of the machine goods industry). It was further shown that Ricardo's machinery substitution argument (3) presupposes very special assumptions about the available set of production methods from which producers can choose, and thus is not of general validity.

It was then suggested, based on textual evidence from Knut Wicksell's contributions, that the 'machinery substitution effect' may have played an important role in the emergence of the marginalist principle of factor substitution with regard to capital and labour. But, while Wicksell clearly perceived Ricardo's different analytical approach to the determination of prices and income distribution, and to the problem of the choice of technique, with its asymmetric treatment of the distributive variables, later marginalist authors wrongly interpreted Ricardo's machinery substitution argument from the background of the their own analytical approach, which attempted a simultaneous and symmetrical determination of the factor input proportions and *all* factor prices (including a factor called 'capital'). While the Ricardo effect thus seems to have played some role in the emergence of the marginalist factor substitution principle with regard to capital and labour, it nevertheless cannot be regarded as an anticipation of the latter.

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NOTES

1. In his Preface to a German reprint of *Preise und Produktion*, Hayek even referred to the 'Ricardo effect' as 'a better and more general presentation of the main ideas expounded in this book' (Hayek 1976, p. vi; my translation).
2. In *Business Cycles* (1939) Schumpeter had referred to the lengthening (or shortening) of the average period of production triggered by changes in the money rate of interest as the 'Hayek effect'. In *History of Economic Analysis* (1954) he no longer made use of this notion but now adopted Hayek's term, 'Ricardo effect', in the context of an assessment of Ricardo's contributions to economic analysis. According to Schumpeter, the notion refers to 'a particular

theorem: if wages, say, rise, the relative prices of goods into the production of which "fixed capital" or "fixed capital" of high durability enter largely will fall, and the relative prices of goods "which are chiefly produced by labour with less fixed capital or with fixed capital of a less durable character than the medium in which price is estimated will rise", a proposition that has been dubbed in our time, the Ricardo Effect' (Schumpeter 1954, p. 595).

3. Kaldor contended that Ricardo's argument is 'really exactly the same as the familiar Austrian proposition that when the rate of interest rises, the costs of production, and hence the prices, of goods containing more capital will rise relatively to those containing less capital, and this will cause a substitution of the latter for the former, all along the line' (1942, p. 366). Ferguson (1973, pp. 6–7) claimed that Ricardo was concerned with the case of a rise in the real wage rate, which raises the price of corn and lowers the price of machines (leaving the average price level unchanged), and he suggested that Ricardo's machinery substitution argument 'inevitably entails the assumption that the production of corn is labour-intensive relative to the production of machinery. I cannot find an explicit statement to this effect in Ricardo; but it is obviously required, for otherwise an increase in the real wage would increase the price of machinery by more than the price of corn' (1973, p. 7). Blaug similarly opined that Ricardo's 'machinery substitution effect' was based on the tacit assumption 'that labour costs in the machine goods industry are less than the average of labour costs in the economy as a whole—so that the rise in money wages does not produce a proportionate rise in the price of machines' ([1962] 1997, p. 523).

4. It is immediately obvious that Ricardo's argument is independent of his simplifying assumption that the machine is produced by 'unassisted labour in the course of a year', and also holds good if the workers are 'assisted' by circulating and/or fixed capital in the production of the machine. Equation (1) could be replaced with

$$(1^*) \quad \omega_0 L_d = p_m = \omega_0 [L_{m1}(1 + r_0) + L_{m2}(1 + r_1) + \dots + L_{mn}(1 + r_n) + \dots],$$

where L_{mi} ($i = 1, 2, \dots, \infty$) denotes the amounts of labour embodied directly and indirectly in the machine. Instead of inequality (2), we would then have

$$(2^*) \quad \omega_1 L_d > \omega_0 [L_{m1}(1 + r_1) + L_{m2}(1 + r_2) + \dots + L_{mn}(1 + r_n) + \dots].$$

5. Whewell's notation has been adapted to that used in this paper.

6. A corollary of Ricardo's argument is that the prices of the commodities produced by machines must fall in 'absolute value' (that is, in their money price), and must fall relative to the price of provisions. This latter effect, however, is not identical with the so-called 'price effect', since the relative cheapening of these commodities results not from the fact that their production is relatively less labour-intensive than that of provisions, but rather from the fact that the amount of labour per unit of output of these commodities has fallen, while the amount of labour per unit of output of the latter has increased.

7. In Jevons's case, substantial evidence has been provided for the claim that the theory of capital which he set out in *The Theory of Political Economy* resulted very directly from the application of the classical theory of intensive rent to the factor 'capital'; cf. Bharadwaj (1986, pp. 44–5) and Steedman (1997). Moreover, there are clear indications that Jevons himself perceived of his theory of interest as being closely related to the classical theory of rent; see e.g. Jevons ([1871] 1965, pp. 1 and 210). As regards Böhm-Bawerk, there is no indication, either in his discussion of Ricardo's theory of profit in the *History* (Böhm-Bawerk [1884] 1921a) or in his *Positive Theory* (Böhm-Bawerk [1889] 1921b), that he was directly inspired by Ricardo's machinery substitution argument in developing the specifically Austrian version of the capital–labour substitution principle in terms of the shortening or lengthening of the production period.

8. For an English translation of the relevant paragraph, see Stigler (1949, p. 284).

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