1 A value-theoretic critique of the Okishio theorem

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1.1 INTRODUCTION

This chapter will vindicate Marx's contention that mechanization can cause the rate of profit to fall. It will assume profit maximizing behaviour and a constant real wage, and thus demonstrate precisely that which the Okishio (1961) theorem is generally thought to have refuted. The 'catch', as it were, is that value will be conceived as I believe Marx conceived it, as a quantum of dead labour owing its existence to the extraction of living labour, and existing in historical time. It will not be conceived as an equilibrium magnitude derived from technological data or as an incidental numéraire in an equilibrium model in which only relative prices (values) matter.

It is no accident that I here reiterate themes voiced elsewhere in this volume, in connection with the transformation of values into production prices. Since Bortkiewicz (1952), the attempts to show logical inconsistency in Marx's profit rate theory and in his account of the value-price transformation have gone hand in hand; the modern, 'Sraffian' critique of Marx kills the two birds with one model. Conversely, McGlone and I (Kliman and McGlone 1988), by repudiating that model and its conception of value, vindicated Marx's account of the value-price transformation. Emerging from that exercise was the recognition that our alternative conception of value was the foundation upon which Marx's law of the falling rate of profit could be defended against the Okishio theorem (Kliman 1988).[1] Independently, on the basis of similar critiques of the Sraffian concept of value, Ernst (1982) and Alan Freeman (see this volume) have also developed rather similar models of falling profitability due to mechanization.

By rooting falling profitability in mechanization, these works differ from the better known critiques of the Okishio theorem, as I discuss in section 2. Section 3 contrasts the Sraffian concept of profitability with Marx's, laying the groundwork for section 4's demonstration that the profit rate can fall due to mechanization itself. Finally, section 5 provides several reasons why profit maximizing capitalists would adopt such mechanized techniques. Before turning to these issues, however, I wish to comment briefly on the significance of the debate surrounding the falling rate of profit.

The global capitalist economy is now entering its third decade of slump. Growth of output and productivity have declined markedly throughout this period in the West and in Japan. The same story holds for Eastern Europe and Russia, even before the accelerated economic collapse of the past few years. The 1980s are commonly spoken of as 'the lost decade' for both Latin America and Africa.

Official unemployment in OECD countries has more than tripled over this period. In the USA, an increasing share of those who escape official unemployment can only find temporary and/or part time jobs offering low or no benefits or security.

Especially in the USA, economic ideologues are responding to the slump by calling for, and state and corporate planners are implementing, policies intended to enhance international 'competitiveness' by lowering costs and raising productivity. This vision of the future thus offers us more of the present – more automation, robotization and unemployment, intensification of labour, new threats in the workplace to life and limb; unionbusting; and lower wages, benefits, and income support – plus, of course, promises that 'prosperity is just around the corner'.

Both the crisis of automation and working people's search for a different future, a new way of working and living, were foreshadowed as far back as 1950. In that year, automation was first introduced in the form of the 'continuous miner'. Called the 'mankiller' by the coalminers, it would soon bring permanent mass unemployment to Appalachia. Yet 'with automation, *the workers* began to question the very mode of labour. Thus they began to make concrete, *and thereby extended*, Marx's profoundest conceptions' (Dunayevskaya 1992:102). These conceptions were not those of the 'young Marx' alone; it was the mature Marx of *Capital*, Volume III who analysed the falling rate of profit thus:

> The *true barrier* to capitalist production is *capital itself*. It is that capital and its self-valorisation appear as the starting and finishing point, as the motive and purpose of production; production is production only for *capital*, and not the reverse, i.e. the means of production are not simply means for a steadily expanding pattern of life for the *society* of the producers'. (Marx 1981:358)

If indeed the production of capital as an end in itself is capitalist production's immanent barrier and source of crises, then '[t]he true realm of freedom, the development of human powers as an end in itself' (Marx 1981:959) is neither mere rhetoric nor utopian morality. On the contrary, this humanist perspective becomes the concrete, practical alternative to capitalism and its unending crises – and not only as a goal, but also as the way to achieve it. The development of human powers as an end in itself is inherently a process of *self-development* as well as a goal. Its realization therefore requires that the separation of ends and means, and the division between thinkers and doers, begin to be broken down in the here and now, not put off until 'after the revolution'.

The very opposite impact of the Okishio theorem has been to turn radical theorists' attention away from the capitalist mode of *production*, its labour process, and towards forms of distribution and competition. It has exerted a decisive influence over recent theories of the falling rate of profit and the contemporary world economic crisis. The theorem purports to demonstrate that, if the real wage rate remains constant, mechanization introduced by profit maximizing capitalists cannot, in and of itself, lower the equilibrium profit rate. Thus, rising real wages are the true source of falling profitability. Marx's contention that the rate of profit must fall because of incessant mechanization, even if workers labour 24 hours a day at zero wages (Marx 1981:523), is simply wrong.

1.2 CRITIQUE OF OTHER CRITIQUES

Various critiques of the theorem have shown that the profit rate can in fact fall. By themselves, such demonstrations do not vindicate *Marx*'s theory of the falling profit rate against Okishio. His theorem does not purport to show the impossibility of a falling profit rate. Rather, as Roemer (1981:113, my emphasis) has stressed, 'the problem has been to understand whether a FRP [falling rate of profit] can be construed to be due to technical innovation *itself*, independent of changes in the real wage'. In most prior critiques, something other than mechanization *itself* causes the profit rate to fall.

One critique, for instance, abandons Okishio's assumption of a constant real wage as unrealistic and shows that the profit rate can fall when real wage increases accompany mechanization (Laibman 1982; Foley 1986; Lipietz 1986). Yet since the fall is due to rising wages, not mechanization *per se*, Okishio's critique of Marx's theory emerges unscathed.

A different critique, suggested by Alberro and Persky (1981), posits the unexpected appearance of new techniques that yield a higher potential stream of returns than existing techniques. If this is a recurrent phenomenon, existing techniques again and again become unexpectedly obsolescent and are scrapped prematurely. Because they fail to yield their full stream of potential lifetime returns, the rate of profit may fall. While it is undeniable that capitalists lack perfect foresight, it should be noted that, again, it is not mechanization itself, but this lack of foresight, that causes the profit rate to fall in the Alberro-Persky model. Unless one can adduce some inherent, systematic bias to capitalists' expectations of technological advance, moreover, the falling rate of profit in this model rests on a contingent phenomenon, in contrast to the lawful, necessary character of the fall in Marx's own theory.

The theorem has also been shown to be invalid when joint products are produced (see, for example, Giussani 1986). This demonstration is more promising as a vindication of Marx's theory, since it does focus on how mechanization itself affects the profit rate. Like the Alberro-Persky model,

however, it rests on a purely contingent factor, in this case the mathematical characteristics of particular technologies.

Much controversy has surrounded the Shaikh-Nakatani critique of the Okishio theorem, which suggests that cut-throat competition forces firms to adopt 'suboptimal' techniques, that is, techniques failing to yield the highest profit rate when 'costed up' at current equilibrium prices. Shaikh's (1978) paper was widely misinterpreted as arguing that firms are forced by competition to maximize profit margins *instead of* profit rates; he (Shaikh 1987) later endorsed Nakatani's (1979) paper, which argues in terms of profit rate maximization. For Nakatani, cut-throat competition takes the form of price reductions. Firms adopt the technique that will maximize their profit rates when their prices are forced down to some minimum acceptable level, instead of the technique that yields the highest profit rate at current equilibrium prices, as the Okishio theorem assumes. Because the technique chosen is suboptimal, its adoption can result in a falling rate of profit. Yet in whatever way it is interpreted, the cut-throat competition argument fails to defend *Marx's* theory of the falling rate of profit. As Giussani (1986) has noted, the Shaikh–Nakatani view diverges from Marx's by positing the competitive process, not mechanization itself, as the root cause of declining profitability.

Of course, Marx recognized that 'Capital exists and can only exist as many capitals' – a phrase widely quoted by those who would turn one particular form of appearance of capitalism, characterized by competition and private ownership, into an immutable 'essence' of capitalism.[2] Yet the remainder of the sentence reads: '… and *its self*-determination therefore *appears* as their reciprocal interaction with one another' (Marx 1973:414, my emphases). Marx's point was that competition manifests and enforces the inner laws of capital, but does not invent them or impose them externally on capital. As he wrote later in the same work:

> Smith explained the fall of the rate of profit, as capital grows, by the competition among capitals … as if competition imposed laws on capital from the outside, laws not its own. Competition can permanently depress the … rate of profit, only if and in so far as a general and permanent fall of the rate of profit, having the force of a law, is conceivable *prior to* competition and regardless of competition. Competition executes the inner laws of capital; makes them compulsory laws toward the individual capital, but it does not invent them. (Marx 1973:751-52)[3]

Thus, Marx argued from the inner nature of capital outward: mechanization, the growing preponderance of dead over living labour stemming from the drive to expand relative surplus value, results in falling profitability; this in turn unleashes a cut-throat competitive struggle (Marx 1981:361, 365). For Shaikh and Nakatani, conversely, cut-throat competition induces mechanization.[4] The tendency for the rate of profit to fall is therefore absent, and a falling profit rate is inconceivable, apart from competition. Competition here not only executes the laws of capital, but also invents them and imposes them on capital from the

outside. This strand of the literature therefore ends up by criticizing the outer form in which capital appears, only to give capitalist production relations themselves a clean bill of health.

A possible response to this objection is that Shaikh and Nakatani have simply engaged Okishio on his own terrain, one that assumes the presence of competition. This is false. While Okishio and subsequent *theorists* are concerned with competition and its consequences, the Okishio theorem itself does not require competition or multiple firms. While it does depend on profit rate maximizing behaviour, its conclusions for a profit maximizing, isolated, 'planned' state-capitalist society are the same as for a competitive, private capitalist one. Indeed, when only a single capital and one output exist, the proof is almost tautological (see Appendix, part I).

An adequate defence of Marx's theory must therefore show that mechanization itself can lower the profit rate, 'independent of changes in the real wage' (Roemer 1981:113) *and* 'regardless of competition' (Marx 1973:752).

1.3 CONTRASTING CONCEPTS OF THE RATE OF PROFIT

Profitability, for Marx, expresses the degree to which accumulated, dead labour is augmented by the surplus labour pumped out of living labourers in capitalist production. In the Okishio theorem, profitability – at least in equilibrium – expresses the degree of physical productivity. The theorem's refutation of the law of the falling rate of profit rests on this difference, not competition. Its 'bottom line' is simply that, given constant real wages, new techniques adopted by profit maximizing firms to raise their own profitability are so productive that they cannot, in the end, lower the general profit rate.

While the theorem is undoubtedly a landmark, its underlying conflation of value production and use value production is ubiquitous. As noted above, today's economic ideologists propose reversing capitalism's long term economic slump through high tech and productivity increases. Prior to Okishio, moreover, several other theorists undertook to refute Marx's theory of the falling profit rate; all rooted their critiques in the notion that greater productivity translates into greater profitability.[5]

As Ernst (1982) and Naples (1989) have recognized, the theorem (and the Sraffian model generally) measure profitability in physical or quasi-physical terms, as the 'self-expansion' of use value. In a one sector ('corn') model, its profit rate is what Ernst terms the 'material rate of profit': the ratio of surplus corn (corn output minus corn input) to corn invested. Yet in multisector versions, too, profitability is computed solely from physical data and relative prices (themselves only ratios of physical quantities), without reference to either money or labour time. Hence, if corn is the numéraire, the terms of the profit rate reduce

to corn equivalents and the profit rate is computed as the rate of 'self-expansion' of corn equivalent.[6]

Such profitability measures implicitly assume that a *unit of corn at harvest time is worth exactly as much as a unit at planting time (and at the moment of investment), irrespective of any changes over time in the labour time needed to produce it or in its money price*. Two interpretations of this assumption are possible. First, as a metaphysical materialist primitive: value is a veil, only relative prices (ratios of things) matter. A thing's 'value' *is* the quantity of another thing it commands. A unit of corn commands a unit of corn, so it is always selfsame economically as well as physically.

This denial of a commodity's 'intrinsic value' (Marx 1976a:126) is precisely what Marx strove to overthrow, in his critique of Bailey (Marx 1972:124ff) and in *Capital*'s opening pages. By treating value as the capitalistic *relation between* a thing and the social labour time needed for its production, he sought to destroy the independence fetishistically imputed to the world of things (Marx 1972:129). Hence, if the Okishio theorem indeed relies on a 'use value theory of value' (Naples 1989:146-47) alien to Marx in order to refute his theory, it refutes nothing, demonstrates no internal inconsistency. As will be shown in section 4, technical change that raises the 'material rate of profit' can lower the Marxian value (and price) rate.

A second interpretation of the Okishio theorem is possible, however. It is a comparative static equilibrium exercise. 'Absolute' values (and prices) play no role in static equilibrium measurement, so even if values (and prices) are determined by labour time, the profit rate is still expressible in terms of relative prices (physical quantities) alone.

This is correct. Yet treated as a comparative static equilibrium exercise, the theorem sorely lacks the generality that would be needed to refute Marx. It treats mechanization as a one-time-only 'disturbance', while even a cursory reading of Marx's law of the falling tendency of the profit rate reveals that it refers to continuous mechanization:

> The *progressive tendency* for the general rate of profit to fall is thus simply the *expression, peculiar to the capitalist mode of production*, of the *progressive development* of the social productivity of labour. … Since the mass of living labour applied *continuously declines* in relation to the mass of objectified labour that it sets in motion … the part of this living labour that is unpaid and objectified in surplus-value must also stand in an *ever-decreasing ratio* to the value of the total capital applied. But this ratio … constitutes the rate of profit, which must therefore *steadily fall*. (Marx 1981:319)[7]

Hence, by failing to treat mechanization as continuous, the Okishio theorem neither refutes this law nor even bears any clear relationship to it. Moreover, that the theorem appears to refute Marx has everything to do with its treatment of mechanization as a disturbance of static equilibrium. It relies crucially on the unproved assumption that the economy 'fully adjusts' to a new static equilibrium

after mechanization (see Appendix, part I). Under continuous mechanization, however, full adjustment will not occur and the Marxian profit rate can fall.

This will be demonstrated in section 4. Here I wish to note that, given continuous mechanization (and in general, outside of static equilibrium), the Okishian profit rate is a defective measure of the rate of 'self-expansion' of value. The theorem, and the Sraffian model generally, use the same price vector to value fixed capital,[8] inputs, and outputs. Outside of static equilibrium, this is illegitimate, tantamount to a *retroactive* revaluation of old fixed capital and preproduction inputs at postproduction prices. Since mechanization *itself* tends to lower values over time, it is inadmissible to ignore intertemporal changes in values when assessing the impact of mechanization on profitability. If preproduction inputs and (especially) old fixed capital are revalued according to lower, postproduction values, the capital advanced to production – the denominator of the profit rate – is reduced artificially, raising the profit rate artificially. To ignore intertemporal reductions in values is to sweep under the rug a key immanent obstacle to capital's self-expansion of already existing value.

To put the issue in accounting terms, the Sraffian model values assets at replacement cost instead of historical cost (actual purchase prices). While replacement cost valuation is appropriate for some purposes, historical cost valuation must be used to ascertain the actual movement of profitability over time. Just as, from the standpoint of capital's inner nature, the profit rate is the rate at which value 'self-expands', from the standpoint of the practical manager and state planner, the profit rate is the rate of return on their actual, original investment.

This point has been made by others, in somewhat different ways (Ernst 1982; Harvey 1982; Weeks 1982), and not only as a belated attempt to circumvent the Okishio theorem. In a 1946 essay, Dunayevskaya (1991:43; cf. Dunayevskaya 1981f:442) argued that

> [t]he constant technological revolutions make the time necessary to *reproduce* a product tomorrow less than the time it took to *produce* it today. Hence there comes a time when all commodities … have been 'overpaid.' The crisis that follows is not caused by a shortage of 'effective demand' … that 'inability to sell' manifests itself as such *because of the fundamental antecedent decline in the rate of profit, which has nothing whatever to do with the inability to sell.*

By reducing unit values over time, in other words, mechanization itself causes the 'overaccumulation' of capital: yesterday's capital, acquired at higher values, is too large relative to today's lower valued output. The immanent devaluation of commodities eventually manifests itself in a lack of new value to acquire inputs and workers, and thus sell – at the old, higher values.[9] Devaluation is manifested outwardly in and through crisis.

On the other hand, declining unit values also result in the devaluation of capital assets. A contradiction between historical and replacement costs develops. Yet when mechanization's immanent devaluation of capital is made manifest, the contradiction is resolved: capital does eventually become revalued in practice at

its new, lower reproduction cost. This tends to raise the profit rate. Here Marx and the Sraffians agree. Yet this contradiction, too, is 'resolved' in and through crisis, through the *forcible* reduction of old values to the new. Whereas the Sraffian model treats devaluation as an unalloyed blessing to the capitalists, as if capital is wiped off the books painlessly and ahistorically, without entailing capital losses, Marx (1981:358, 362ff) recognizes that it involves the eradication of already existing capital, through physical destruction, bankruptcies, the writing-off of capital losses due to falling asset prices, and so on. All such processes imply a lower, not higher, rate of return on the *original* outlay of capital.

Measurement of the profit rate at devalued capital values (replacement costs) therefore accurately appraises the actual rate of return on investment only at the trough of the slump, after so much capital has been annihilated that it is again profitable to resume the normal course of business. Even then, replacement cost measurement only expresses a new potential of capital to 'self-expand' – a potential that will not be realized when mechanization begins again to reduce values, and so on. It is not an exaggeration, then, to understand the comparative static equilibria of Okishio's model as a comparison of slumps.

The foregoing analysis implies that, though mechanization produces continuous declines in unit values and profitability, these processes need not and generally will not manifest themselves as such. The reduction in values will generally not be reflected in falling prices when business is brisk; that is, until the crisis produces a sudden 'deflation'. Largely for this reason, the 'observed' rate of profit typically reflects the continuous tendency of the profit rate to fall only discontinuously, in recurrent crises.[10]

It is beyond the scope of this chapter to model the movement in the observed profit rate. The discussion below is confined to an investigation of the *tendency* of the rate of profit – that is, to the historical movement of the rate of profit considered in abstraction from the forms in which it appears. It will thus be assumed that new commodities and capital are valued at their current historical value and existing capital is 'kept on the books' at its historical value.

1.4 THE PROFIT RATE UNDER CONTINUOUS MECHANIZATION

This section shows that the Okishio theorem's treatment of mechanization as a single episodic disturbance is crucial to its result. An alternative, continuous 'model' of mechanization is then developed. Given the determination of value by labour time and historical cost valuation of capital, it is shown that the profit rate under continuous mechanization tends to diverge systematically from the 'material rate of profit' and can fall when the latter rises. Indeed, if the extraction

of living labour does not increase as the economy grows, the profit rate approaches zero over time.

Initial assumptions

Roemer (1981, Chapter 5) has generalized Okishio's theorem to include nondepreciating fixed capital. A single-capital/one-output version of that generalization, adapted for continuous mechanization (in discrete time), is developed here. The real wage per unit of living labour extracted, *w*, is constant. Q, F, A, and N stand for output, (nondepreciating) fixed capital, circulating constant capital, and living labour. To subject Marx's law of the falling rate of profit to a very strong test, I assume a form of mechanization that keeps the (constant) capital/output ratio unchanged. For simplicity, growth is assumed. Thus Q, F, and A all grow at the same rate; b (> 1) is their growth factor (1 + growth rate). The growth factor of living labour extracted is c. Under continuous mechanization, $c < b$ (but one-time-only mechanization will also be considered).[11] Thus output per worker and the technical composition of capital both rise continuously. Solving difference equations of the form $Q_{t+1} = bQ_t$, one obtains

$$Q_t = Q_0 b^t \quad (1)$$
$$F_t = F_0 b^t \quad (2)$$
$$A_t = A_0 b^t \quad (3)$$
$$N_t = N_0 c^t \quad (4)$$

The path of unit value and price

In considering one-time-only mechanization, the Okishio theorem models a single change in technical coefficients. Thereafter they (and the real wage) remain constant. Hence, given growth of output, adjustment to a post-mechanization static equilibrium depends solely on the full adjustment of prices from pre- to postmechanization levels. To show the fragility of this unproved assumption and to simplify profitability computations, I here develop intertemporal value and price equations based on Marx's concept of value.

Marx holds that the total value of output is the sum of the value of the used up circulating constant capital, preserved in production and transferred to the value of output, plus depreciation of fixed capital (assumed = 0 here), plus the value added through the extraction of living labour in capitalist production. Call V_t the unit input value in period t; the unit input value of period $t + 1$ is, then, V_{t+1}. One period's inputs consist of the previous period's outputs, so V_{t+1} is also the unit output value of period t. One can therefore write

$$V_{t+1}Q_t = V_tA_t + N_t \quad (5)$$

Dividing by Q_t and substituting the solution values from (1), (3), and (4), one obtains a unit value equation

$$V_{t+1} = V_t a + n(c/b)^t \quad (5')$$

where $a = A_0/Q_0$ and $n = N_0/Q_0$, for which the solution is

$$V_t = (V_0 - n/[c/b - a])a^t + (n/[c/b - a])(c/b)^t \qquad (5'')$$

(except in the unimportant case, not considered here, in which $c/b = a$). Assuming the economy yields more output than it uses as material input, $a < 1$.

Now to consider price as distinct from value. In Marx's theory, 'price, taken by itself, is only the *monetary expression of value*' (Marx 1971:35). As the universal measure of value, money is ever present, even in the absence of exchanges, since it 'serves only in an imaginary or ideal capacity' (Marx 1976a:190).[12] Since a single sector and a single capital are assumed here, we have a case of price 'by itself'; no redistribution of surplus value causes deviations of individual prices from values. The 'monetary expression of value' can be represented using ε, a factor indicating the quantity of the monetary unit that represents a unit of socially necessary labour time (Foley 1982). The relationship between unit price 'by itself' and unit value is thus

$$p_t \equiv \varepsilon_t V_t \qquad (6)$$

where p_t is the unit price. Assuming ε is constant, so that purely nominal deviations of price from value are ignored, (5″) multiplied by ε gives the intertemporal path of the unit input price:

$$p_t = (p_0 - \pi)a^t + \pi(c/b)^t \; ; \; \pi = \varepsilon n/(c/b - a) \qquad (7)$$

V_0 and p_0 are initial, premechanization magnitudes. In the case of one-time-only mechanization, Q_0, A_0, and N_0 (and F_0) can be treated as the magnitudes prevailing *immediately after* mechanization, which all grow at the same rate thereafter. Hence $c = b$. As time proceeds, (7) converges in this case to the static equilibrium price $p_e = \varepsilon n/(1 - a)$, proportional to the labour time needed to reproduce a unit of net product. As noted above, given one-time-only mechanization (with growth thereafter), price convergence implies that the profit rate converges to a postmechanization static equilibrium level.[13] Confirmation of this assumption likewise confirms Okishio's theorem in this case.

In the case of continuous mechanization, Q_0, A_0, and N_0 (and F_0) can be treated as *premechanization* magnitudes. As time proceeds, the amount of labour needed per unit output falls continuously (since $c < b$), so the unit price in (7) asymptotically approaches zero. Yet it is incorrect to infer that a new static equilibrium price – a new identity of input and output prices – is approached. Were that the case, the ratio p_{t+1}/p_t would converge to one over time, but it follows from (7) that

$$\lim_{t \to \infty} \left(\frac{p_{t+1}}{p_t} \right) = \begin{matrix} c/b \text{ if } a < c/b \\ a \text{ if } a > c/b \end{matrix} , \qquad (8)$$

a number always less than one. The unit price converges to what is known as a moving equilibrium level, not a static equilibrium.

Under a regime of continuous mechanization, then, historical and replacement costs of a unit of capital do not converge, but increasingly diverge. The

replacement cost continually falls (ignoring purely nominal differences between price and value), while the historical cost, of course, remains unchanged. Assume, for example, the following data: $a = 0.5$, $b = 1.05$, $c = 1.008$, $n = 0.92$, and $\varepsilon = 1$. The initial, premechanization static equilibrium price is $p_0 = \varepsilon n/(1 - a) = 1.84$. Substituting the data into (7), one obtains $p_t = -0.16(0.5)^t + 2(0.96)^t$, upon which Table 10.1 is based.

Table 10.1

After 40 periods, a unit of fixed capital acquired in period 0 could be replaced at 21 per cent of its original cost. This cheapening of the elements of constant capital implies not a higher rate of 'self-expansion' of value, but a lower rate: everything else being equal, the rate of return on the original outlay of capital is only 21 per cent of what it was initially.[14] Or, were the fixed capital suddenly revalued at its replacement cost in the 40th period, 79 per cent of its original value would be annihilated.

Everything else does not remain equal, of course. While the divergence between historical and replacement costs implies that 'too much' was paid for capital today by the standards of tomorrow, new capital is acquired more cheaply and, when the real wage remains constant, profit per unit output will continuously rise. The net effect of these consequences of continuous mechanization must now be examined explicitly.

Capital itself as the barrier to capitalist production

For simplicity, assume a premechanization static equilibrium. The profit rate is

$$r_0 = \frac{p_0 Q_0 - p_0 A_0 - p_0 w N_0}{p_0 Q_0 + p_0 A_0 + p_0 F_0}$$

$$= \frac{1 - a - wn}{a + wn + f} \tag{9}$$

where $f = F_0/Q_0$. (9) will be useful as a benchmark with which the 'material rate of profit' and the value/price rate of profit can be compared.

As noted above, the material rate of profit, r^m, expresses the rate of 'self-expansion' of use value. Alternatively, it can be regarded as the static equilibrium equivalent of the value/price rate of profit, that is, the rate of profit calculated on the basis of replacement costs. Since fixed capital, inputs, real wage components, and output all have the same unit price in static equilibrium, the unit price cancels out in profit rate calculations, leaving a profit rate that, again, expresses a ratio of physical quantities alone. For the sort of continuous mechanization under consideration, the material rate of profit is

$$r^m_t = (Q_t - A_t - wN_t)/(A_t + wN_t + F_t)$$

which, using (1) – (4), can be rewritten as

$$r^{m}_{t} = (1 - a - wn[c/b]^{t})/(a + wn[c/b]^{t} + f), \tag{10}$$

so that, as time proceeds

$$\lim_{t \to \infty} \left(r_t^m\right) = \frac{1-a}{a+f} \tag{10′}$$

The limit of the material rate of profit is clearly greater than the premechanization rate, r_0 (unless workers live on air). The ratio of constant capital to output $(a + f)$ remains unchanged but, as the wage cost per unit of output diminishes continuously, the material rate of profit rises continuously, asymptotically approaching its limit, (10′).

To compute the value/price profit rate, it is necessary to introduce a new term, K_t, the total (historical) value of the fixed capital in period t, that is, the sum of monetary investment in fixed capital over time. Each increment to the fixed capital is valued at its historical cost, so that the cost of any increment depends on when it was acquired. Formally,

$$K_t = \sum_{0}^{t} p_t(F_t - F_{t-1}) \tag{11}$$

The value/price rate of profit, calculated on the basis of historical costs, is

$$r_t = (p_{t+1}Q_t - p_tA_t - p_twN_t)/(p_tA_t + p_twN_t + K_t), \tag{12}$$

but since, using (5) and (6), one can write

$$p_{t+1}Q_t - p_tA_t = \varepsilon N_t \tag{13}$$

then

$$r_t = (N_t[\varepsilon - p_tw])/(p_tA_t + p_twN_t + K_t) \tag{12′}$$

If $c < 1$, that is, if mechanization leads to an absolute decline in the extraction of living labour (N), the profit rate approaches zero over time. The numerator of (12′) – the mass of profit – declines to zero as time proceeds, while the value of the capital stock (K) and thus the denominator of the profit rate remain positive. Even if $c = 1$, so that extraction of living labour stays constant, the profit rate still approaches zero, because the mass of profit stagnates while the value of the capital stock rises without limit.

These propositions are proved in the Appendix, part 2, A and B. It should be noted that they hold even though both output per worker and the rate of surplus value (s/v) become infinite over time. Expressed as a ratio of money terms,

$$s/v = (\varepsilon N_t - p_twN_t)/p_twN_t = (\varepsilon - p_tw)/p_tw$$

which rises without limit as the unit price, and thus the value of labour power, approach zero. Hence, *if extraction of living labour fails to increase, the profit rate must tend towards zero, irrespective of any and all increases in productivity or decreases in the value of wages*, and in striking contrast to the continuous rise in the material profit rate.

In Marx's theory, as (13) indicates, the new value generated in any period is only the (money expression of the) living labour extracted in that period. If the latter fails to increase, then profit must eventually stagnate. It should be clear that

in (5) and (13), labour time does not function as a convenient numéraire, but expresses the fundamental proposition of Marx's value/surplus value theory. Control and use of other people's labour is the organizing principle of the capitalist system, the only fuel on which the capitalist engine runs. Expulsion of living labour through mechanization spells the doom of the system.

When expulsion is only relative, that is, when $c > 1$, evaluation of the profit rate is aided by using (3), (4), and (7) to rewrite (12′) as

$$r_t = \frac{n[\varepsilon - (p_0 - \pi)wa^t - \pi w(c/b)^t]}{(p_0 - \pi)[a(ab/c)^t + wna^t] + \pi[a + wn(c/b)^t] + K_t/Q_0c^t} \tag{14}$$

Part 2C of the Appendix shows that all terms containing time superscripts vanish as time proceeds, except K_t/Q_oc^t, which rises to the limit

$$\pi f(c/b)[(b-1)/(c-1)].$$

Using the full expression for π in (7), one thus obtains

$$\lim_{t \to \infty} r_t = \frac{1 - ab/c}{a(b/c) + f[(b-1)/(c-1)]} \tag{14′}$$

Comparison of (10′) and (14′) shows that the value/price and material profit rates tend to two different limits under continuous mechanization. The limit of the material rate is always higher. It is easily shown analytically that the material rate is higher in every period. Neither result depends wholly on the presence of fixed capital; even when $f = 0$, the value/price rate and its limit are lower than the material rate and its limit because the output price is always lower than the input price.

While the material rate always rises asymptotically to its limit, the behaviour of the value/price rate may be rather complex. The main factors governing its movement are the initial value of labour power and the pace of mechanization. It will tend to rise (fall) at first when the initial value of labour power is high (low), and it will ultimately fall (rise) when mechanization is rapid (slow) – that is, when b/c is high (low).[15] (Table 10.2 illustrates the movements of the two profit rates, using as data $a = 0.4$, $n = 0.2$, $\varepsilon = 1$, and thus $p_0 = 1/3$, as well as $w = 0.5$, $f = 2$, $b = 1.06$, and $c = 1.02$.)

Table 10.2 Profit rate comparisons over time

As (14′) indicates, moreover, the tendency of the value/price rate is very sensitive to the pace of mechanization – of which the term $(b - 1)/(c - 1)$ provides an index. *Ceteris paribus*, the greater this pace, the greater is the tendency of the profit rate to fall.

The value/price profit rate may or may not fall in the sense of its limit being lower than the premechanization profit rate r_0. The relationship between them is influenced by the pace of mechanization, the initial value of labour power, and the output/constant capital ratio. The higher the initial value of labour power or output/constant capital ratio, the greater is the pace of mechanization needed to produce a falling rate of profit. Given the pace of mechanization, the higher the initial value of labour power, the lower the output/constant capital ratio must be if the profit rate is to fall.

This exercise has thus not demonstrated that the rate of profit must fall, though it has shown that it will fall if the extraction of living labour fails to increase or if the pace of mechanization is rapid enough. It bears repeating, however, that the law of the tendency of the rate of profit to fall has faced two very strong tests here – not only the constancy of the real wage rate, but also the constancy of the output/constant capital ratio.

1.5 MICRO-ENFORCEMENT OF THE LAW

Would a profit maximizing capitalist adopt the mechanized techniques modelled above? There are several possibilities to consider here. The capitalist might ‘cost up’ the next period’s technique at the current price, or at the static equilibrium price corresponding to the present technique. The expected profitability of the new technique might be compared to the present period’s value/price rate, or to the current material rate.

As long as the same set of prices is used to value output, inputs, and fixed capital, each possible combination of these methods would indicate that the new technique should be adopted. Since the same price is used to cost up all terms in the expected profit rate, it is identical to next period’s material rate. As we have seen, the latter is higher than the current material rate and thus higher than the current value/price rate as well. The board of directors or central planning agency would therefore always ‘give the go ahead’ to the new technique.

It is reasonable to object that the capitalist might anticipate the fall in the unit price, and therefore not use a constant price to evaluate the new technique. Yet it should be noted that the Okishio theorem itself assumes expected profitability calculations are made on the basis of current prices – even though labour time values will fall throughout the system when the new technique is employed. Hence, as a refutation of the theorem, the demonstration above is sufficient.

Even if the fall in the unit price is anticipated, however, the new technique might be adopted under competitive conditions. As Marx (1981:373-74) argued,

the innovating firm's profit rate might rise because its higher productivity enables it to reap superprofits while its competitors' profit rates and the general profit rate fall. The Okishio theorem seemed to refute this argument, but only because it seemed to show that a new technique that caused the innovator's profit rate to rise could not lower the general rate of profit. By refuting the theorem, this chapter has likewise vindicated Marx's argument.

As an illustration of this process, consider a one sector capitalist economy consisting of an innovating firm, I, and its competitors, C. As in the example above, the data for the total social capital are $a = 0.4$, $n = 0.2$, $\varepsilon = 1$, $p_0 = {}^1\!/_3$, $w = 0.5$, $f = 2$, $b = 1.06$, and $c = 1.02$. The initial market shares of I and C are 10 per cent and 90 per cent, respectively. Beginning from a static equilibrium with I and C having the same technology (and thus the same *a*, *n*, and *f*, above), C does not innovate, but grows at 4 per cent per period ($b^C = c^C = 1.04$). I's output and inputs change at the rate needed to ensure $b = 1.06$ and $c = 1.02$ for the total social capital.[16] The general rate of profit is again computed from (5), (6), (11), and (12). Individual profit rates are computed analogously, except that all purchases and sales are made at the *social* price, expressing the average, socially necessary labour time needed to produce the commodity, given by (5) and (6).

Table 10.3

Table 10.3 gives the individual and general profit rates through period 5. Consistent with Marx's argument, I's profit rate rises, while C's and the general rate fall. Since the data for the total social capital are the same as in Table 10.2, moreover, the general rate of profit in each period is exactly the same, although Table 10.2 and the discussion until now abstracted from competition. This illustrates the meaning of Marx's contention that competition manifests and enforces the law of the falling tendency of the rate of profit, a law which, however, 'is conceivable *prior to* competition and regardless of competition' (Marx 1973:752).

Finally, it is crucial to recognize that mechanization can be put into effect, not only because of intercapitalist competition, but because of a type of 'competition' inherent in the capital/labour relation itself: the antagonism between worker and machine. The Okishio theorem, and bourgeois economics generally, treats wages as being paid, not per unit of labour power hired, but per unit of actual labour activity. It is thus known *ex ante* how much output will result, not only from given physical inputs and labour activity, but also from given money outlays. It is as if the purchase of labour power in the market guarantees that the gears of industry will turn smoothly.

In capitalism, however, the payment of wages bears no monotonic relation to the amount of labour sweated out of working people. To turn labour power into actual sweated labour, the capitalist reduces workers to appendages of machines, exercises the raw power of management, and so on. But the power of workers 'trained, united and organised by the very mechanism of the capitalist process of production' (Marx 1976a:929) always threatens to raise the wage rate per unit of *labour actually performed*, or per unit of *output actually produced*, to uncontrollable and unacceptable levels, through strikes, slowdowns, increased supervisory costs, and so forth; and the workers' potential to take control of production is ever present. In such an environment of 'uncertainty', techniques of production cannot be costed up in the manner assumed by the Okishio theorem; only after production is completed can the wage rate per unit of labour extracted be known with certainty. Moreover, very good microeconomic reasons suggest to the capitalist that profitability depends on reducing this uncertainty. Mechanization is the key way in which s/he tries to gain control of the factory, to further the implementation of his/her 'purely despotic' plan (Marx 1976a:450), and thus to raise expected profitability. This is the 'microfoundation' of the falling rate of profit that pertains to any and all forms of capitalism. It is a 'rising organic composition' theory; it is a 'class struggle' theory. The two are the same.

> But machinery does not just act as a superior competitor to the worker, always on the point of making him superfluous. It is a power inimical to him, and capital proclaims this fact loudly and deliberately, as well as making use of it. It is the most powerful weapon for suppressing strikes, those periodic revolts of the working class against the autocracy of capital. According to Gaskell, the steam-engine was from the very first an antagonist of 'human power'. (Marx 1976a:562)

In absolute opposition to capital's drive to subdue human power by replacing it with machine power, which gives rise to the falling tendency of its profit rate and its crises, Volume III of *Capital* holds forth the vision of a 'true realm of freedom, the development of human powers as an end in itself' (Marx 1981:959).

1.6 APPENDIX

I. The Okishio theorem

Roemer (1981, Chapter 5) generalized Okishio's theorem to include nondepreciating fixed capital. A single-capital/one-output version of that generalization follows. Premechanization magnitudes are denoted with, and postmechanization magnitudes without, a zero superscript (for example, F^0).

The theorem is an argument in three steps:

(a) Assume an initial static equilibrium, with a static equilibrium (timeless) price prevailing:

$$p^0Q^0 = r^0p^0F^0 + (1 + r^0)p^0(A^0 + wN^0)$$

which implies that

$$r^0 = (Q^0 - A^0 - wN^0)/(A^0 + wN^0 + F^0) \qquad (I.1)$$

(b) The capitalist will adopt a new technique if and only if it is expected to result in a higher profit rate, according to calculations made on the basis of the *current* static equilibrium price, profit rate, and real wage rate. Adoption of the new technique thus requires

$$p^0Q > r^0p^0F + (1 + r^0)p^0(A + wN)$$

from which it follows that

$$r^0 < (Q - A - wN)/(A + wN + F) \qquad (I.2)$$

(c) Finally, adjustment to a new static equilibrium is assumed (not proved), with p and r as the new equilibrium price and profit rate:

$$pQ = rpF + (1 + r)p(A + wN)$$

implying that

$$r = (Q - A - wN)/(A + wN + F) \qquad (I.3)$$

Since the expressions on the right hand sides of (I.2) and (I.3) are identical, $r > r^0$.

II. Mathematical fine points

Note that:

(i) p_t approaches zero from above over time (as shown in text);

(ii) $ab = 1$ would imply $A_{t+1} = Q_t$, but some Q_t must be used for wages, and so on, so $ab < 1$; and

(iii) equation (11) can be rewritten, using (2) and (6), as

$$K_t = F_o[p_o + (p_o - \pi)(1 - 1/b)\sum_1^t (ab)^\tau + \pi(1 - 1/b)\sum_1^t c^\tau]$$

A. The profit rate approaches zero over time if $c < 1$. Proof: Refer to (12′). ($c < 1$ and (i)) implies that N, and the numerator of (12′), approach zero over time. Since the increment to K in any period is the positive unit price times the positive change in fixed capital, K continually increases, so the denominator remains positive. Q.E.D.

B. The profit rate approaches zero over time if $c = 1$. Proof: Refer to (12′). ($c = 1$ and (i)) implies that N, and the numerator of (12′), reach a finite limit over time. Refer to (iii). The first term in square brackets is constant. Given (ii), the second term approaches a finite limit over time. $c = 1$ implies that the third term, and thus K_t, and thus the denominator of (12′), increase without limit. Q.E.D.

C. Refer to (14). a, $c/b < 1$. ($c > 1$ and (ii)) implies that $ab/c < 1$. Thus a^t, $(c/b)^t$, and $(ab/c)^t$ approach zero over time. Refer to (iii). The first term in square brackets is constant and, given (ii), the second reaches a finite limit over time. Hence, when $c > 1$, each approaches zero over time when divided by c^t. In the third term, Σc^τ divided by c^t is $c\Sigma(1/c)^\tau$, also summed from 1 to t, which rises to the limit $c/(c - 1)$. Hence K_t/Q_0c^t rises to the limit $\pi f(c/b)[(b - 1)/(c - 1)]$.

ACKNOWLEDGEMENTS

An abbreviated version of an earlier draft of this chapter was published as 'The Profit Rate Under Continuous Technological Change', in the *Review of Radical Political Economics* (Kliman 1988). I wish to thank Cyrus Bina, Howard Botwinick, Paresh Chattopadhyay, Stephen Cullenberg, Massimo DeAngelis, Shaun Hargreaves Heap, David Laibman, Jeannette Mitchell, Gary Mongiovi, Fred Moseley, Michael Perelman, and the other contributors to the present volume for their incisive comments and discussions of the issues. The usual caveat applies.

NOTES

[1] For the sake of clarity, it must be noted that my research has not sought to reconceptualize value in order to replace a flawed tool of economic analysis with a superior one. I regard Marx's concept of value as a category of his dialectical presentation of the real movement of capitalistic society, not as a tool of investigation. Moreover, my research is not intended to develop an alternative political economy, but to reclaim and contribute to the *critique* of political economy on the foundations laid by Marx. For an elaboration of this distinction, see the chapter by McGlone and Kliman in the present volume.

[2] '[C]ompetition is an essential feature of capitalism; capital can only exist in the form of many capitals' (Elson 1979b:168).

[3] See also Marx (1976a:433): 'The general and necessary tendencies of capital must be distinguished from their forms of appearance … a scientific analysis of competition is possible only if we can grasp the inner nature of capital, just as the apparent motions of the heavenly bodies are intelligible only to someone who is acquainted with their real motions, which are not perceptible to the senses'.

[4] Nakatani actually reverses the causation to a greater extent, rooting cutthroat competition in a prior lack of aggregate demand, whereas Marx roots the shortfall in demand in the antecedent fall in the rate of profit. Shaikh does not explain the source of the cutthroat environment but, given that competition induces mechanization in his approach, the source could not be falling profitability stemming from mechanization itself.

[5] In 1899, just five years after the publication of *Capital*, Volume III, Tugan Baranowsky and the Italian philosopher Benedetto Croce independently critiqued Marx's law along these lines. Bortkiewicz (in 1907), Moszkowska (in 1929), and Shibata (in 1933) also anticipated Okishio. See Howard and King (1989:188-90, 198; 1992, Chapter 7) for references and discussion.

[6] Imagine, for simplicity, two sectors without fixed capital and the following input-output relations (with wages included among inputs): (I) 12s, 8c yield 24s; (II) 2s, 4c yield 12c (s is steel, c is corn). Assuming uniform profitability and stationary prices, the 'corn price' of steel is 2: 1 unit steel = 2 units corn. The profit rate is

$$\frac{24s + 12c}{14s+12c} - 1 = \frac{48c + 12c}{28c+12c} - 1 = \frac{60c}{40c} - 1 = 0.5$$

indicating a 50 per cent expansion of corn-equivalent.

[7] The phrase ' the expression … production' was emphasized in the original; other emphases are added.

[8] Okishio's original theorem ignores fixed capital, but Roemer's (1981, Chapter 5) later generalization includes it.

[9] 'Part of the commodities on the market can complete their process of circulation and reproduction only by an immense reduction in their prices, i.e. by a devaluation in the capital they represent' (Marx 1981:363).

[10] See Perelman's (1993) excellent discussion of crises as discontinuous, nonperiodic manifestations of technical change and asset devaluation. See also Moseley's (1993c) argument that, due to the restoration of profitability during slumps, Marx's law does not imply a long-run decline in the observed profit rate.

[11] The parameters are implicitly restricted to ensure that output in each period is greater than or equal to the next period's production requirements. Given that $c \leq b$, if this restriction is met in the initial period, it will be met thereafter.

[12] I therefore reject Ernst's (1982) contention that money and price cannot exist in a one-output model. In his model, capitalists are unable to recognize the fall in the value rate of profit because value relations find no monetary expression. This leads him to the absurd conclusion that the falling rate of profit neither leads to crisis nor influences capitalists' behaviour. Instead, the system breaks down due to *material* overaccumulation.

[13] This result can be confirmed by comparing the limit of the value/price rate of profit (14′) with the limit of its static equilibrium counterpart (10′), below. When $c = b > 1$, the two profit rates converge to the same limit.

[14] For example if the ratio of output to fixed capital is 1, then (total revenue)/(value of fixed capital), initially 1, falls to 0.21 by period 40.

[15] It can also be shown that, when real wages are zero or the rate of surplus-value is held constant, the value/price profit rate must decline continuously to its limit--even though the ratio of constant capital to output is fixed. In contrast, the material profit rate remains constant through time in both cases.

[16] For example, if $Q_0 = 1250$, then $Q^C_0 = 1125$, and $Q^I_0 = 125$; and $N_0 = 250$, $N^C_0 = 225$, $N^I_0 = 25$. Given the growth rates, $Q_1 = 1325$, $Q^C_0 = 1170$, so $Q^I_1 = 155$; and $N_1 = 255$, $N^C_0 = 234$, so $N^I_1 = 21$.