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Aggregate capital productivity in the US economy, 1964–2001

Simon Mohun*

In the decomposition of the US macroeconomic pre-tax rate of profit as the product of profit share and capital productivity, this paper considers the role of capital productivity over the period 1964–2001. The primary finding is that prior to 1982 capital productivity fell because capital deepening proceeded faster than labour productivity growth, whereas from 1982 to 1997 the opposite occured. If, prior to 1982, the US economy was characterised by Marx-biased technical progress, what requires explanation is why labour productivity continued to grow after 1982 in the absence of sufficient capital deepening. The paper explores various hypotheses, contrasts neoclassical and classical notions of technical change, and investigates the robustness of its results to the productive–unproductive distinction and to accounting for changes in capacity utilisation.

Key words: Capital productivity, Labour productivity, Productive labour, Unproductive labour, Rate of profit
JEL classifcations: E11, O47, O51

1. Introduction

A theory based on a vision of society characterised by class conflict over the production and appropriation of surplus value entails that the central category of macroeconomics is not gross domestic product (GDP) and its growth over time, but the macroeconomic rate of profit and its trend over time. For the US economy, to a considerable extent this is a well-worked field (recent work includes Duménil and Lévy, 2002B, and Wolff, 2001), and the basic features of the trend in the US rate of profit are well-known. However it is precisely measured, the pre-tax net rate of profit fell sharply from 1966 through to 1982, recovered to about its 1973 level by 1997, and then fell sharply again, so that by 2001 the rate of profit was lower than at any time other than the trough of 1979–83. The usual approach is to decompose the rate of profit into the product of profit share and capital productivity in

Manuscript received 1 April 2005; final version received 10 June 2008.
Address for correspondence: School of Business and Management, Queen Mary University of London, Mile End Road, London E1 4NS, UK; email: s.mohun@qmul.ac.uk

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order to investigate what has proximately determined this movement; the present study follows this approach.

It should be noted at the outset that, in a significant sense, the term 'capital productivity' is misleading. Labour productivity is an important concept because labour produces commodity outputs. But, in the context of the labour theory of value, means of production as fixed (and circulating) capital do not; they serve only to facilitate the production of output by labour. Productivity, the production of an increased volume of use-values per unit of time thereby cheapening each unit of output, is an attribute of labour, not of means of production. But 'productivity-facilitating-means-of-production' is hardly elegant, and is abbreviated here to 'capital productivity'. It should not thereby be presumed that means of production produce anything. Similarly, 'capital', in the classical tradition, being 'money that creates more money via a particular metamorphosis of form' is rather different from 'fixed assets', but the meaning of any particular usage should be clear from the context.

In analysing the decomposition of the US rate of profit, the approach taken here differs from most of the literature[1] in that it attempts to give empirical content to classical theoretical categories. In particular, the paper distinguishes productive from unproductive labour, and hence the wages paid to productive labour from the wages paid to unproductive labour. It similarly identifies as productive the net fixed assets of the industries in which productive labour is employed, and as unproductive the net fixed assets of those industries that employ no productive labour. From the perspective of profitability and its measurement, there is no difference between productive and unproductive wages: they are both costs. Equally, and for the same reason, there is no difference between productive and unproductive net fixed assets. But analytically the productive/unproductive distinction critically bears on profitability in the sense that only productive labour (working with productive capital) creates surplus value (value added in money terms less wages paid to productive labour), and profits are defined inclusively as all value added in money terms not paid out in wages (to productive and unproductive labour). Thus trends in productive labour and the means of production with which it works determine what is potentially available for profits, while trends in unproductive labour determine how much is actually available.

These distinctions are highly contested (Mohun, 2003). However, following methods of calculation outlined previously (Mohun, 2005), Mohun (2006) showed that there is an almost exact equivalence in time trends of US distributive shares between an account based on the controversial distinction between productive labour [45–48% of total employment in full-time equivalents (FTEs)] and unproductive labour (52–55% of FTE employment), and one based on a much less controversial classification based on hierarchy: whether workers are 'supervisory' (some 17–18% of FTE employment, and around a third of all unproductive labour) or 'non-supervisory' (some 82–83% of FTE employment, embracing all productive labour and about two thirds of all unproductive labour). It turns out, at least for the US economy over the period of this study, that trends in distributive shares based on the productive–unproductive distinction can be proxied by trends in distributive shares relating to non-supervisory ('production') workers and 'supervisory' workers.

While the profit share was examined by Mohun (2006), this paper focuses on capital productivity. It adds weight to the conjecture that the classical presumption of capital-using labour-saving (or Marx-biased) technical change is a reasonable interpretation of the data

[1] Moseley (1991) is an exception.

for the period up to 1982. But its major focus is to show that this is not the case for the period after 1982, when labour productivity continued to increase in the absence of capital deepening. It appears that the nature of technical progress changed. In exploring why this might have been the case, a variety of issues have to be confronted. These include capital aggregation, neoclassical technical progress and the meaning of total factor productivity in growth accounting approaches, classical technical progress and its representation in empirical measures, and methods of deflating the nominal capital stock to obtain quality-adjusted constant-price ('real') measures.

Attempting to measure carefully what it is that requires explanation, within an accounting framework informed by a Marxian approach, is different from providing that explanation. Typically, more effort goes into the latter than the former, and one motivation underlying the paper is that this ranking of priorities should be questioned. There is a large literature on 'explanations', most recently prompted by Brenner (1998), who proposed that the decline in US profitability was caused by an intensification of international competition in manufacturing, leading to systemic overcapacity and overproduction, whose resolution for capital requires more exit from manufacturing than has so far occurred. This thesis has generated considerable controversy on both theoretical and empirical grounds, with extensive subsequent debate [examples, from a large field, include Duménil and Lévy (1999, 2002A); Shaikh (1999); Zacharias (2002), and replies by Brenner (2002A, 2002B)], but this controversy is not considered here. The focus of this paper is rather on determining what it is that has to be explained.

The paper is organised as follows. The next section considers briefly the empirics of the profit rate and its decomposition into the product of profit share and capital productivity. The profit share was examined by Mohun (2006), and the main findings are summarised prior to an examination of capital productivity. The next section explores a detailed decomposition of capital productivity, the measurement of its components and the sensitivity of that measurement, both to the productive–unproductive distinction and to issues concerning capacity utilisation. This is followed by an assessment of the importance of the different elements of the framework of this decomposition. The major focus here is on the ratio of labour productivity to capital intensity, and a discussion of how and why this ratio has changed over the period. Finally, a conclusion draws the various threads together, summarises the main results and indicates some directions for future research.

2. Rate of profit and its decomposition

The rate of profit (r) is here taken as the ratio of pre-tax profits (Π) to the money value of the capital stock (K) of net fixed assets plus inventories:

$$r = \frac{\Pi}{K} \tag{1}$$

In terms of trend, the rate of profit in the US economy halved between 1965 and 1982, recovered to about its 1973 level by 1997, and thereafter fell sharply to approach its 1979–83 levels by 2001. Proximate determinants of these trends are approached by decomposing the rate of profit into the product of profit share and capital productivity. Both of these terms require a measure of aggregate net value added in money terms, and (as in Mohun, 2006) this is taken to be proxied by net domestic product less compensation of general government employees less the imputations for GDP.[1] This aggregate is taken to be money

[1] Plus some adjustments to the imputations to avoid double counting. See Appendix A1 for further details.

value added (MVA) and is the exact equivalent of the hours of productive labour, the two being linked by the value of money.[1] Then the profit share is Π/MVA, capturing trends in distributive shares, and capital productivity is MVA/K, capturing trends in technology and accumulation, so that

$$r = \left(\frac{\Pi}{MVA}\right)\left(\frac{MVA}{K}\right) \quad (2)$$

Profit rate, profit share and capital productivity are depicted in Figure 1, indexed to 1964. In terms of annual average compound rates of growth, from 1965 to 1982 the fall in the profit share accounted for about 53% of the fall in the profit rate, and that of capital productivity for about 47%. In accounting for the rise in the profit rate from 1982 to 1997, these proportions were almost exactly reversed.

While a proximate explanation of trends in the rate of profit has therefore to focus on both profit share and capital productivity, it should be noted that these are not independent determinants of the rate of profit. It is straightforward to decompose the profit share into the difference between real output per hour (labour productivity) and the real hourly wage rate, as a proportion of labour productivity, so that the rate of change of the profit share is determined by the difference between the rate of growth of labour productivity and the rate of growth of the real hourly wage rate. Likewise, in the decomposition of capital productivity, the major determinant [see equation (7), below] is the ratio of labour productivity to capital deepening (real fixed assets per hour). Hence, while it is convenient to decompose the rate of profit according to equation (2), the causal factors have to be sought in the determinants of labour productivity, the value of labour power, price movements and the nature of technical change.[2]

3. Profit share

Profits are here defined as the difference between money value added and wages:

$$\Pi = MVA - W \quad (3)$$

Wages are made up of wages of 'production workers' (around 82% of non-farm employees) and wages of 'supervisory workers', or $W(pn)$ and $W(s)$ respectively. A 'production worker' is one who has no supervisory responsibilities, and is a category defined by the Bureau of Labor Statistics (BLS) of the US Department of Labor (1994); 'supervisory workers' are constructed as the difference between total employees in employment and production workers. If the major divisions of the Standard Industrial Classification (SIC) are classified in terms of the classical categories of 'unproductive' [circulation activities (wholesale and retail trade, finance, insurance and real estate, legal services, most business services, some miscellaneous professional services) and general government] and 'productive' (all other activities), then production worker wages are the sum of the wages of production workers in productive sectors, denoted $W(pn, p)$, and the wages of production workers in unproductive sectors, denoted $W(pn, u)$. The former is total productive wages, the latter, together with $W(s)$, is total unproductive wages. Then equation (3) can be rewritten in terms of share as

$$\frac{\Pi}{MVA} = 1 - \frac{W(pn, p)}{MVA} - \frac{(W(pn, u)}{MVA} - \frac{W(s)}{MVA} \quad (4)$$

[1] For further details of this approach, see Foley (1982, 1986) and Mohun (1994).
[2] Distinguishing productive and unproductive labour and capital complicates but does not alter this causal hierarchy.

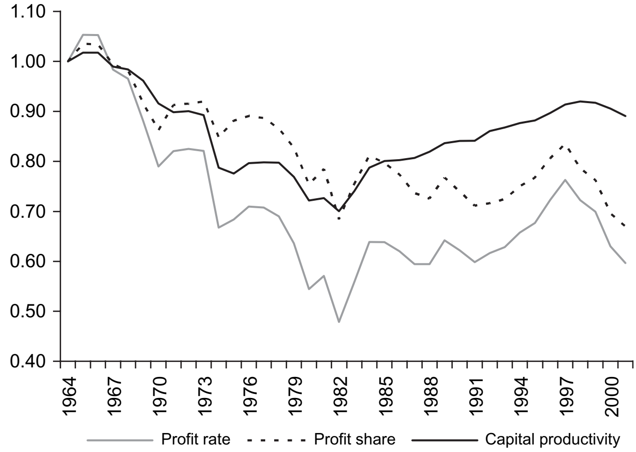

Fig. 1. *Rate of profit, profit share and capital productivity, USA, 1964–2001 (1964 = 1).*

These ratios were explored by Mohun (2006), who showed that the wage share of production workers in unproductive sectors had changed little over the whole period. If profits are a residual, changes in the profits share were entirely determined by time trends in the productive labour wage share (the value of labour power) and in the supervisory labour wage share. It follows that a description of trends in the profit share in terms of trends in the wage shares of productive and unproductive labour, and one in terms of trends in the wage shares of production workers and supervisory workers, are empirically the same, at least for the period 1964–2001. That is, in terms of trend, the number, wages and hours worked by productive labour are captured by the number, wages and hours worked by production workers.

It was further proposed by Mohun (2006) that those in authority can be treated as bearers of the capital relation, so that the labour income of the capitalist class can be proxied by the labour income of supervisory workers. Then the capitalist class share is an expanded profits share, the sum of the shares of profits and the labour income of supervisory workers, and this expanded profits share follows the same time trend as the share of money surplus value in MVA. Rearranging equation (4):

$$\frac{\Pi}{MVA} + \frac{W(s)}{MVA} + \frac{W(pn,\,u)}{MVA} = 1 - \frac{W(pn,\,p)}{MVA} \tag{5}$$

where the first two terms on the left hand side comprise the expanded profit share and all three terms together comprise the share of surplus value in MVA (with the third term broadly constant). Letting $w(pn, p)$ and $H(pn, p)$ denote the wage rate and the hours worked by productive labour, RMVA the constant price money value added, and $P(MVA)$ the money value added deflator (approximated by the net domestic product implicit deflator), then equation (5) can be rewritten as

$$\frac{\Pi}{MVA} + \frac{W(s)}{MVA} + \frac{W(pn,\,u)}{MVA} = 1 - \left[\frac{w(pn,\,p)}{P(MVA)}\right] \Big/ \left[\frac{RMVA}{H(pn,\,p)}\right] \tag{6}$$

so that trends in both the expanded profit share and the share of money surplus value are determined by the difference over time between the rate of growth of the real (product) wage rate of productive workers and the rate of growth of labour productivity.

From 1964 to 1979, these shares were fluctuating around a flat trend, indicative of a stalemate in class struggle. The value of labour power was correspondingly roughly constant, as hourly real wage rates of productive workers grew in line with productivity. Hence, the fall in profit share over this period is entirely accounted for by a rise in the wage share of supervisory workers. But there was a dramatic change after 1979, with a major shift in the balance of power towards capital. The value of labour power fell for the remainder of the century (as productivity grew but hourly real wage rates for production workers did not), so that the rate of surplus value (the ratio of money surplus value to the wages of productive labour) increased by about 40%.

Figure 2 shows the *rate* of surplus value, the profit *share* reproduced from Figure 1, and the expanded profit *share* (the sum of the profit share and the wage share of supervisory workers), all indexed to their 1964 levels. The increase in the rate of surplus value from 1982 to 2001 financed a small increase in production workers in unproductive sectors (the unproductive working class: share of employment up by 1.7%, share of hours up by 3.8%, share of wages up by 3.5%). And it also financed a change in the weight of supervisory workers (share of employment *down* by 3.8%, share of hours *down* by 5.2%, share of wages *up* by 19.6%). Thus, almost all of the increase in the rate of exploitation found its way into the labour income of supervisory workers. Hence, a major issue in the study of the profit share is to explain why the increase in the rate of surplus value benefitted not the profit share but rather the labour income of supervisory workers.[1]

4. Capital productivity

4.1. Decomposition

Analogous to labour productivity as output per unit of labour input, 'capital productivity' (the inverse of the conventionally defined capital–output ratio) attempts to capture some notion of the efficiency with which fixed assets are used in the production of output. But the analogy is not perfect. However heterogeneous the labour input, there is at least a 'natural' physical measure in terms of hours, whatever adjustments are then made to those hours. But as regards the heterogeneous means of production comprising fixed capital, there is no such 'natural' measure, and the best that can be done is to measure in terms of units of money. Further, while labour productivity requires a measure of real output, capital productivity is a ratio of two money magnitudes in different sets of prices. Each of these magnitudes is the product of a price index and a constant price variable. Let $P(i)$ denote the price index of money aggregate i (where i is either MVA or a measure of the capital stock), let p continue to denote the descriptor 'productive', and denote constant price variables by the corresponding nominal variable prefixed by R (for 'real'). Then

$$MVA = P(MVA)RMVA$$

Let $K(pn, p)$ denote that portion of the capital stock with which productive labour works. Then

$$K(pn,p) = P[K(pn,p)]RK(pn,p)$$

[1] Piketty and Saez (2003) and Duménil and Lévy (2004) discuss the huge inequalities within the labour income of supervisory workers, but these are not the issue here.

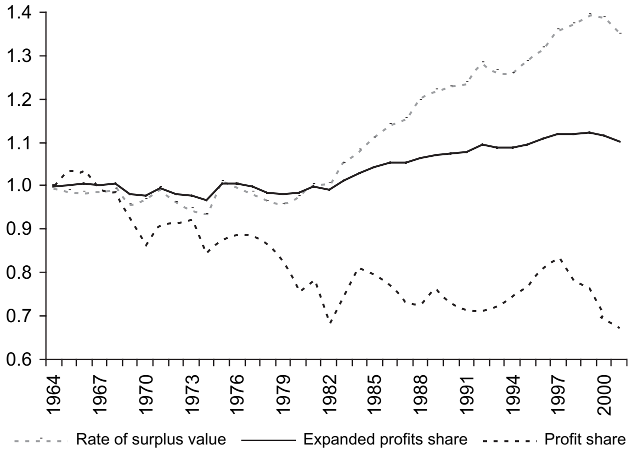

Fig. 2. *The rate of surplus value, expanded profit share and profit share, USA, 1964–2001 (1964 = 1).*

Henceforth, for notational simplicity, the label (pn, p) will be abbreviated simply to (p). Then capital productivity can be decomposed in the following way:

$$\frac{MVA}{K} = \frac{K(p)}{K}\frac{MVA}{K(p)} = \frac{K(p)}{K}\left(\frac{P(MVA)}{P\ [K(p)]}\right)\frac{RMVA/\,H(p)}{RK(p)/\,H(p)} \qquad (7)$$

so that movements in capital productivity can be considered in terms of changes in the three ratios on the right hand side of equation (7), respectively:

(1) the structure of the capital stock: the proportion of the productive capital stock to the total capital stock;
(2) relative prices;
(3) the relation between labour productivity and capital intensity.

4.2. *Measurement*

These three ratios are represented in terms of average annual rates of growth in Table 1 over the two periods of the fall in capital productivity: from its peak in 1966 to its trough in 1982 and its rise from that trough to its peak in 1998.

4.3. *Sensitivity*

Two immediate issues arise out of the decomposition of capital productivity in Table 1. One concerns the conceptual framework of productive and unproductive labour and what difference the distinction makes; the second concerns the lack of any adjustment for capacity utilisation and what difference such adjustment would make. These are treated in turn.

4.3.1. Productive and unproductive sectors A framework that distinguishes between productive and unproductive labour, and hence the capital with which each works as productive and unproductive capital, is controversial. While the framework itself is subject to considerable disagreement, what is at issue here is the extent to which that framework makes a difference to the measures involved in the decomposition of capital productivity. Consider again the three terms on the right-hand side of equation (7), and call the first

Table 1. *Components of capital productivity: average annual rates of growth, USA 1966–1998*

				Percentage per annum			
Row				1966–82		1982–98	
1		$K(p)/K$			–0.05		–0.6
2		$P[K(p)]/P(MVA)$			0.9		–0.7
3	$RMVA/H(p)$			1.5		1.4	
4	$RK(p)/H(p)$			2.9		–0.2	
5	3 – 4 =	$(RMVA)/[RK(p)]$			–1.4		1.5
6		1 – 2 + 5 =	MVA/K		–2.3		1.7

term 'capital structure' (denoted CS, row 1 in Table 1), the second term 'relative prices' (denoted RP, the inverse of row 2 in Table 1), and the third 'real capital productivity' (RCP, row 5 in Table 1). Then, in terms of annual growth rates (*rog*), equation (7) becomes

$$rog\frac{MVA}{K} = rog(\mathrm{CS}) + rog(\mathrm{RP}) + rog(\mathrm{RC}P) \tag{8}$$

Expressing each rate of growth as a percentage of the rate of growth of (nominal) capital productivity gives an indication of the relative weight of each growth rate and in this sense the relative importance of each variable in accounting for movements in (nominal) capital productivity. Table 2 puts the information in Table 1 into this form, and then reworks the calculations for the case where there is no distinction between productive and unproductive labour. Abandoning the productive–unproductive distinction makes very little difference to the proximate explanation of the decline in capital productivity, which, in growth rate terms, remains dominated by the average annual growth rates of relative prices and the relation between labour productivity and capital intensity in similar orders of magnitude.

However, the proximate explanation of the upswing in capital productivity changes, for exactly the same reason as in the explanation of movements in the profit share. In an aggregate value theoretic framework, any expansion of the unproductive sector has to be financed by the productive sector. If, for example, the share of unproductive wages rises, this can only occur if the rate of exploitation of productive labour increases, so that there is sufficient surplus value in money terms to finance (through unequal exchange) the wages of unproductive labour. Those sceptical of the distinction will see this as a tautology: any expansion of the unproductive sector *must* be accompanied by an equivalent measured increase in surplus value in money terms if the latter is to be the source of the payment of the former. Those advocating the distinction will impose a theoretical prior of causation: *because* the rate of surplus value increases, a space is created for the expansion of unproductive sectors. Then the issue becomes why unproductive sectors expanded relatively, and how (a portion of) the surplus value originating in the productive sector is monetised in unproductive sectors. So too with capital productivity: imposing a productive–unproductive distinction increases the importance of RP by about a quarter and that of RCP by about a third, because the (smaller) stock of productive fixed assets and inventories has more work to do in accounting for the overall change in capital productivity. Put another way, while output is invariant to the productive–unproductive distinction, inputs are not, and there was a large relative expansion of employment in unproductive sectors in the 1980s and 1990s, particularly in business services and finance, insurance and real estate,

Table 2. *Allowing for and ignoring the productive–unproductive distinction: percentage of the average annual compound rate of growth of capital productivity accounted for by the rates of growth of the constituent elements of its decomposition*

		Percentage	
		1966–82	1982–98
From Table 1			
Row 1/row 6	CS	2.0	–33.8
Row 2/row 6	RP	40.4	43.2
Row 5/row 6	RCP	57.6	90.6
No unproductive labour	CS	–	–
	RP	40.2	35.4
	RCP	59.8	64.6

with a concomitant relative increase in their net fixed assets. Again, those sceptical of the productive–unproductive distinction will interpret this as a necessary accounting, but devoid of meaning. Those supportive of the distinction will argue that the rise in the rate of surplus value of productive labour *inter alia* enabled the investment that cumulated into this expansion of the unproductive capital stock in the sphere of circulation, reflecting the growing importance of 'financialisation', contracting-out and the like.

4.3.2. Capacity utilisation In measuring labour productivity, no account need be taken of labour that is hired but not used, because typically that does not happen: labour power is not purchased in a lifetime contract with its owner. But capital services are a property of long-lived fixed assets that typically are indeed purchased for their (economic or physical) lifetime, and whether they are not used for periods of that lifetime depends upon the demand characteristics of those periods. Hence there is an issue of the extent to which account should be taken of capacity utilisation.

In a long run study, whether fixed assets are in use or not is irrelevant; money is tied up in them on which a return must be earned. This suggests that issues surrounding capacity utilisation are short run ones, belonging to an analysis of competition. While capacity utilisation might be used to smooth business cycle frequency fluctuations in profit rates to take account of short run demand fluctuations, over the long run its trend should be horizontal.[1] This is mostly, but not entirely, true of the Federal Reserve Board's measure of capacity utilisation. Figure 3 shows annual capacity utilisation data for manufacturing from 1948 through to 2007.[2] From 1948 to 1964 capacity utilisation in manufacturing averaged about 82.5%. But the strains of financing welfare expenditure growth at home and the Vietnam war abroad as the 'golden age' ended saw a distinct downward trend in capacity utilisation from 1964 to 1975, stabilising at the lower average of 79.2% (80.5% for the whole economy) from 1975 to 2007.

[1] Post-Keynesian followers of Kalecki will disagree since, typically, capacity utilisation is an important variable in their theoretical growth models. For a different perspective on measurement, see Shaikh (1999) and Shaikh and Moudud (2004), and for a general survey Corrado and Mattey (1997).

[2] The Federal Reserve Board's series for capacity utilisation for the whole economy only begins in 1967; thereafter it tracks the series for manufacturing closely, although at a slightly higher level.

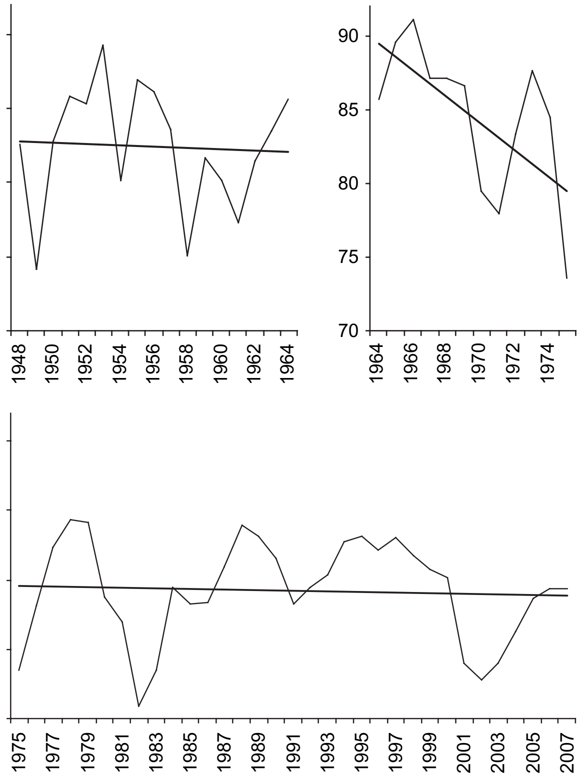

Fig. 3. *Rate of capacity utilisation, manufacturing, Federal Reserve Board, USA, 1948–2007.*

Consequently, the downward trend in capacity utilisation (a symptom of the growing crisis of profitability) for the earlier years of this paper will be absorbed into corresponding movements in capital productivity. This can be seen in Tables 3 and 4. The terms are defined as before, except that RCU denotes the rate of capacity utilisation and RCP* real capital productivity after adjusting for capacity utilisation. Table 3 assumes the productive–unproductive distinction and compares the effects of not adjusting with the effects of adjusting for capacity utilisation. Table 4 presents the same information assuming there are no unproductive sectors. In both Tables 3 and 4 the major effect is in the period 1966–82, in the first half of which the rate of capacity utilisation is trending downwards. Not adjusting for it has the effect of absorbing its trend into the measure of real capital productivity (compare RCP with RCP* in each Table). This does not seem to be a serious problem, as long as it is noted. It is, in any case, unavoidable given that data limitations elsewhere define 1964 as the first year of this study.[1]

5. Why did capital productivity change?

Returning to Table 1, the largest changes are in rows 3 and 4, so that rows 1 and 2 will only be considered briefly.

[1] See the Appendix A2.

Table 3. *Productive and unproductive capital with and without adjustments for capacity utilisation: percentage of the average annual compound rate of growth of capital productivity accounted for by the rates of growth of the constituent elements of its decomposition*

	Percentage	
Productive and unproductive capital	1966–82	1982–98
No adjustment for capacity utilisation		
CS	2.0	–33.8
RP	40.4	43.2
RCU	–	–
RCP	57.6	90.6
With adjustment for capacity utilisation		
CS	2.0	–33.4
RP	39.7	42.6
RCU	13.7	–1.5
RCP*	44.7	92.3

Table 4. *All capital productive, with and without adjustments for capacity utilisation: percentage of the average annual compound rate of growth of capital productivity accounted for by the rates of growth of the constituent elements of its decomposition*

	Percentage	
No unproductive capital	1966–82	1982–98
No adjustment for capacity utilisation		
CS	–	–
RP	40.2	35.4
RCU	–	–
RCP	59.8	64.6
With adjustment for capacity utilisation		
CS	–	–
RP	39.5	35.0
RCU	13.7	–1.5
RCP*	46.7	66.5

5.1. The structure of the capital stock

Movements in the ratio of the productive to the total capital stock were different for the period when capital productivity was falling from that when it was rising.

- Over the years of falling capital productivity, there was no overall change in the ratio. While there was some fluctuation, from 64.5% in 1964 to 62% by 1973 and back to 64.5% by 1981, its effects were overwhelmed by the downward pressures on capital productivity.
- After 1981, the ratio of productive to total capital fell steadily to 58.3% by 1998, most but not all of the fall occurring in the 1980s. For capital productivity to have risen, the negative effects of this fall were dominated by other upward pressures on capital productivity.

5.2. Relative price movements

Falling capital productivity is an indication that technical advances are increasingly difficult and expensive, and conversely for rising capital productivity. Since the capital goods sectors are more capital-intensive than the whole economy (because of the weight of the service sector in MVA), one would expect that relative price movements would simply track the movement of capital productivity. This was indeed the case. When capital productivity was falling (rising), the relative price of capital was rising (falling). The changing pattern of relative prices is shown in Figure 4. From 1964 to 1980, the relative price of net fixed assets and inventories rose by 20.1% as capital productivity fell by 27.8%. Capital productivity continued to fall (by a further 3%) until 1982, whereas the relative price of net fixed assets and inventories was also falling (by 2.7%). Thereafter to 2001, the relative price fell by 11.9% as capital productivity rose by 27.2%.

5.3. The ratio of labour productivity to capital intensity

The third ratio on the right hand side of equation (7) is a measure of 'real capital productivity', the ratio of labour productivity to capital intensity. These are not independent variables, but how the relationship between them is theorised depends upon a prior theoretical choice between a neoclassical and a classical framework.

5.3.1. Neoclassical technical progress The neoclassical approach depends upon a (usually one good) aggregate production function, which represents or summarises all existing technologies, one of which profit-maximising firms choose on the basis of factor prices. As existing more capital-intensive techniques become profitable to adopt, the economy moves along the (static) production function. But this does not account for all of past productivity growth. Because of the assumptions of marginal productivity pricing and constant returns to scale, there is a shortfall in the explanation of output growth by input growth, and this residual difference (total factor productivity) is interpreted as a neutral shift of the production function, which is attributable to technical progress (or indeed anything else that might shift the function).

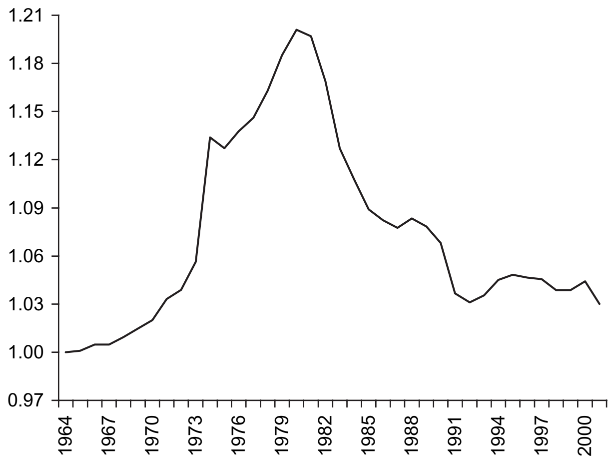

Fig. 4. *Price of net fixed assets and inventories, relative to the price of output (MVA), USA, 1964–2001 (index 1964 = 1).*

There are, however, some major difficulties with this approach. First, within its own conceptual framework, because of diminishing returns, the only long run source of steady state growth in per capita variables is exogenous technical progress. While this is of a piece with the general neoclassical framework, in which the ultimate causal factors rest on exogenously determined preferences, endowments and technology, it renders long run accounts of capitalist development problematic. Second, again granting the neoclassical assumptions, empirical explanation of the post-1973 productivity slowdown has proved intractable, and international differences in income, capital shares, rates of return and convergence are not well explained.

Third, and more radically, Felipe and McCombie in a series of articles[1] have continued earlier work by Phelps Brown (1957), Simon and Levy (1963), Shaikh (1974) and Simon (1979) to argue that the growth accounting approach is, at best, misleading. Beginning with the identity that aggregate value added is the sum of wages and profits, and making no assumptions about either returns to scale or competitive marginal productivity pricing, a simple transformation generates an equation that is identical to the Solovian equation relating total factor productivity (TFP) to the difference between the rate of growth of output and a (factor share) weighted sum of the rates of growth of inputs. Then it is not clear what is being estimated in empirical TFP studies. For suppose it is empirically the case that factor shares are constant, and a weighted average of wage and profit rate growth rates is constant. Since the starting point is a national income identity, a Cobb–Douglas production function can generate an almost perfect econometric fit without assumptions of constant returns to scale and competitive marginal productivity pricing. Further, because the measures of real output and real non-labour inputs are constant price money measures, they do not, and cannot, reflect the underlying technology of individual firms, so that whatever it is that is being estimated, it is not an aggregate summary of the behaviour of individual firms. Felipe and Fisher (2003) suggest that the problem is one of aggregation itself, that the conditions for aggregation are so restrictive that it is quite implausible to consider that a well-behaved aggregate production function can either realistically be derived from the micro production functions of individual firms, or can be considered an approximation for empirical purposes.

It is not clear, however, whether this denies the possibility of meaningful aggregation within the neoclassical framework, or whether it denies the possibility of any plausibly realistic aggregation within *any* theoretical framework. The (predominantly) 1960s Cambridge ‘capital controversies’ showed that any aggregate of capital value could not be used to relate factor payments to factor scarcities via marginal productivity theory, and it is this, rather than aggregation *per se*, that is the point. Indeed, Foley defends aggregation as essential to any non-neoclassical macroeconomic work, arguing that the ‘critical demonstration that the value of capital cannot coherently be used as a capital aggregate to support the scarcity theory of distribution must not distract classical economists from formulating better theories of stability, distribution and growth in which the value of capital will have to play a major part’ (Foley, 2001, pp. 373–4). While positive ways forward from the negative outcomes of the Cambridge ‘capital controversies’ are not settled, it is unambiguous that neoclassical growth accounting hardly emerges unscathed.[2]

[1] See Felipe and McCombie (2003), and references therein.

[2] Cohen and Harcourt (2003) provide a recent retrospect on the Cambridge ‘capital controversies’, in part emphasising the role played by ideology. Temple (2006) defends theoretical work using neoclassical aggregation as a parable, as a way of learning about the world, suggests that the aggregation critique is more serious for empirical work, and surveys some ways in which empirical work in growth economics might avoid the use of aggregate production functions. But on the whole, the neoclassical approach uses growth accounting as though it were theoretically unproblematic. See, for example, Jorgenson and Stiroh (2000), Oliner and Sichel (2000) and Jorgenson *et al.* (2008).

5.3.2. Classical technical progress However, the neoclassical approach is not the only way to theorise choice of technique. It may rather be that choice of technique is no choice at all. While the history of the application of science to production is one of capital deepening, this is not on the basis of a choice among a variety of coexisting techniques. Instead, each successive technique adopted is the most technologically advanced that is available at that time, 'technologically advanced' meaning labour-saving and capital-using, and it is adopted because it is more profitable. Then technical change is embodied in the latest vintage of net fixed assets such that production in any period is typically more 'means of production intensive' than that of the preceding period. The history of this biased technical change could be summarised in a production function, but that would just be a description of past (and now outdated) technical changes, and hence is described as a 'fossil production function' by Foley and Michl (1999) and Michl (1999, 2002).

The choice between this and the neoclassical approach is not one that can be resolved by empirical evidence. For example, consider a macroeconomic one-good world, where technical change is Marx-biased (labour-saving, capital-using), the production technology is Cobb–Douglas, and positive total factor productivity is discovered. Then while a neoclassical economist will assume marginal productivity pricing and interpret positive total factor productivity as a measure of ignorance, a classical economist will deny marginal productivity pricing and interpret positive total factor productivity as merely a device to 'explain' the difference between observed factor prices and their marginal products.[1] The choice is thus a theoretical one, and henceforth this paper follows a classical approach.

In the classical approach then it is this sequence of increasingly automated techniques that causally generates labour productivity growth. Capitals innovate in competitive pursuit of market share. The innovating capital achieves a temporary competitive advantage that is eroded as the innovation is generalised across the industry. As the innovation is more profitable, it allows wage rises, and these prompt further capital-using labour-saving innovation.[2] What is critical then is the relationship between such capital deepening and the rising labour productivity it thereby causes.

Marx considered this through his development of the 'composition of capital' (Marx, 1976, p. 773–4). Because his categories had both a use-value and a value aspect, so he considered the composition of capital in each aspect. From the use-value side, the composition of capital was a notion of the mass of fixed assets employed per worker, which he called the 'technical composition of capital' (TCC). The heterogeneity of fixed assets entails that this is a non-measurable concept. The closest one can get is to render fixed assets commensurable by valuing them at constant (chained) prices; then one can determine 'capital intensity' as a single ratio. It is also more convenient to use worker-hours rather than workers, because the former are the relevant input. So define as a proxy for the technical composition of capital the ratio of a constant price measure of the capital stock $RK(p)$ per hour of productive labour $H(p)$:

$$\mathrm{TCC} \simeq \frac{RK(p)}{H(p)} \tag{9}$$

Henceforth 'capital intensity' and 'TCC' will be used interchangeably, and understood as measured by equation (9). In its value aspect, the composition of capital is a more complex

[1] See Foley and Michl (1999, 2001) and Michl (1999) for further details.

[2] The specification of how technical progress influences the behaviour of wages is not explored in this paper.

category, because if rises in the TCC are how labour productivity is increased, then values are changing. If such value changes are abstracted from (so that attention is confined to the C–C' phase of the circuit of capital), what is valued is just the changes in quantities, and so in value terms the composition of capital must just reflect the TCC. Marx defined this (Laspeyres) reflection of the TCC as the 'organic composition of capital', and his 'value composition of capital' then allowed for changing values. Since the focus here is on the relation between capital deepening and labour productivity increases, which is a matter of use-values, these more complex categories on the value side need not be considered further.

Marx's proposition was that the TCC rose over time, that the way in which productivity was raised was by increasing the means of production with which each worker worked. In a circulating capital world this is obviously true: output per worker rises with an increase in the throughput of raw materials. In a world with fixed capital, however, it is not obvious that technical change should always be capital-using–labour-saving. Firms will innovate if the innovation is cost-reducing (a 'viability' criterion) and what is cost-reducing depends upon the prevailing pattern of unit costs. Marx himself considered innovation to be essentially capital-using–labour-saving, and it is a reasonable empirical observation that this is indeed historically a predominant form of technical change: firms compete through viable capital-using–labour-saving innovations in a productivity war for market share and, hence, profits. But it is not logically the only possibility, so that it is not an ineluctable 'law' that the TCC must rise.

5.3.3. Labour productivity and capital deepening Now consider the last term on the right hand side of equation (7). The numerator is labour productivity and the denominator is the TCC (or capital intensity). These are shown separately in Figure 5, in which each series is indexed to its 1964 level. Consider the period of falling capital productivity from 1966 to 1982. The TCC grew by a total of 45.8%. This growth was not smooth but punctuated by periods of negative growth in 1971–3 and 1975–8. Correspondingly, labour productivity grew by a total of 24.3%, with periods of negative growth in 1973–4 and 1978–9 (and meagre growth from 1979 to 1982). A visual comparison of the slopes in Figure 5 shows how increasingly difficult it was to extract productivity increases from capital deepening and, consequently, the ratio of labour productivity to the TCC fell sharply. Hence the period is aptly characterised as one of Marx-biased technical progress. The period of rising capital productivity from 1982 to 1999 was dramatically different. Overall the TCC barely changed (falling by 1.33%), whereas labour productivity grew by a total of 24.1% (punctuated by negative growth in 1990–1 and 1992–4). Table 5 summarises in terms of average annual growth rates.[1]

In the period of falling capital productivity, an annual growth rate of labour productivity was associated with about double that of the technical composition of capital. In the subsequent period of rising capital productivity, an only fractionally lower annual growth rate of labour productivity was associated with a marginally *falling* technical composition of capital. The two (roughly equal) periods saw almost equal total rises in labour productivity, but whereas the first period was one of capital deepening, the second was one of no capital deepening at all.

Two issues arise. First, what determined the kink in the shape of the graph of capital intensity? Second, why did labour productivity continue to grow in the absence of capital deepening?

[1] In Table 5, 1999 was the peak year of 'real' capital productivity; in Table 1, 1998 was the peak year of overall capital productivity.

Fig. 5. *Labour productivity and capital intensity, USA, 1964–2001 (1964 = 1).*

Table 5. *Annual compound rates of growth*

	Percentage per annum	
	1966–82	1982–99
Labour productivity	1.5	1.4
Technical composition of capital	2.9	–0.1
Real capital productivity	–1.3	1.5

5.3.4. The shape of the graph of capital intensity It is possible that the situation depicted in Figure 5 is confounded by errors in measuring the nominal value of the fixed capital stock. The perpetual inventory method of measuring the fixed capital stock estimates the cumulative value of gross investment (new investment plus net purchases of used assets) through a year, less the cumulative value of depreciation through that year. New investment figures are relatively reliable. There is more uncertainty about the accuracy of depreciation rates of fixed assets, which are geometrically declining through time and are a function of the assumed service lives of those assets. These latter are 'limited with respect to detail and may not fully reflect the effects of changes in business conditions and technology that may have led to variations in service lives over time' (US Department of Commerce, 2003, p. M-8). Similarly, there is more uncertainty about the value of net purchases of used assets because available figures do not include net purchases either between industries or between legal forms of organisation within private business (US Department of Commerce, 2003). But it is difficult to believe that inaccuracies in measuring the level of the nominal value of the fixed capital stock significantly bias its time trend in such a way as to produce the graph in Figure 5.

A related issue concerns the construction of the price indices that are used to deflate the nominal value of the fixed capital stock to determine its real (constant price) value. If deflators do not sufficiently take account of quality improvements, then price inflation will be overstated and corresponding real variables understated. Constant-quality price deflators are based on hedonic estimation and are used along with Fisher chain-type indices to eliminate substitution bias; as of 2001 they accounted for the deflation of some 18% of final expenditures in GDP (Moulton, 2001). For some assets, hedonically estimated prices fell rapidly through time. Thus from 1985 to 1996 the price index for memory chips fell at a 20% average annual rate and that for microprocessors at a 35% average annual rate (Grimm, 1998). By and large, hedonic methods produce consistent results for computers and peripheral equipment (Landefeld and Grimm, 2000). But some four-fifths of final expenditures in GDP is deflated by other methods, and some of these (for example those based on input cost indices) implicitly assume no productivity improvements. Jorgenson and Stiroh (2000) point to consequential possible large understatements in software investment and perhaps communications equipment, and advocate the estimation of constant-quality price indices for a much wider variety of high technology assets, so that growth is reallocated from price growth to quantity growth. Yet computers and peripheral equipment and software remain a very small component of non-residential equipment, software and structures, rising from 1.8% in 1982 to 4.5% in 2000. While this may well be an underestimate because of the failure of deflators adequately to capture quality improvement in high technology industries, it still does not seem plausible to attribute the shape of the graph and its break around 1982 in Figure 5 to measurement error (particularly) in information processing equipment and software industries.[1]

5.3.5. Labour productivity growth after 1982 There are a number of possibilities as to why labour productivity could have continued to rise after 1982 in the absence of capital deepening. One possibility is to focus on input quality, first, that of the capital input, and second, that of the labour input.

As regards the capital input, to the extent that constant-quality price indices are adequately estimated, the data are already adjusted for quality improvements. Nevertheless, as the proportion of information, communications and technology (ICT) equipment and software rose, this could have facilitated more labour productivity per dollar of constant price capital stock. That is, while the constant value aggregate of fixed assets changed little, their composition shifted towards a higher labour-productivity-inducing mix. As a share of the current value of non-residential equipment and software, information processing equipment and software more than doubled from 13.6% in 1964 to 29.7% in 2001, with particularly rapid growth through the 1980s and the second half of the 1990s. As a part of this category, computers and peripheral equipment, and software, rose from 4.8% of non-residential equipment and software in 1982 to 7.1% in 1989 and 11.1% in 2000. But the capital stock figures in the aggregate include non-residential structures, and once these are included computers and peripheral equipment and software were less than 2% of the total aggregate in 1982, and 4.5% some two decades later. Whether this share is large enough to bear the burden of inducing a roughly similar rise in labour productivity that an annual 3% capital deepening managed prior to 1982 is asking a lot. But it also requires saying that the data are substantially inaccurate, for, to the extent

[1] The construction of the other data in Figure 5 [MVA deflated by the net domestic product deflator, and $H(p)$] depend upon the accuracy of the National Income and Product Accounts, and the Employment, Hours and Earnings Survey of the Bureau of Labour Statistics.

that their prices are correctly estimated, the effects of such a compositional change should already be accounted for in the statistics.

As regards the labour input, there is considerable evidence that skill levels have been rising over time. Whereas 10% of jobs required a college degree in 1969, this had more than doubled to 23% by 1985. In 1969, 36% of jobs needed a less than high school education; by 1985 this had fallen to 13% (evidence cited by Green, 2006, p. 31). The hypothesis would have to be that capital deepening and improvements in labour quality combined to produce the growth in labour productivity prior to 1982, and its continued growth after 1982 was due to improvements in labour quality in the absence of capital deepening. But the timing is awkward, for labour productivity growth was higher in the 'golden age' to 1973, and then lower for some two decades or so until the recent acceleration in the second half of the 1990s. Changes in labour productivity growth are not obviously explicable in terms of changes in capital deepening and changes in the skills composition of the labour force.

Another possibility is that there was an increase in the intensity with which the labour input was used, so that each hour of work produced more value added than previously. Some care is needed here, because increased pressure embraces more than work intensity. For example, average weekly hours worked by production workers in all private sector industries fell markedly from 38.7 in 1964 to 34.8 in 1982, and thereafter fractionally to 34.2 in 2001. Because average weekly earnings (in $1982) peaked in 1973 at $315.38, fell to $267.26 in 1982 and rose only to $273.26 by 2001 (roughly the level they had reached in 1962), households were under considerable financial pressure, so that, while individuals worked fewer hours, households worked longer hours. Thus, in 1970 married couples worked on average 53 hours per week, but this had risen to 63 hours per week by 1998 (cited by Green, 2006, pp. 46–7). Yet while this might constitute an increase in 'work–life balance' pressures, it is not an increase in work intensity. Evidence cited by Green (2006, pp. 60–1) suggests some increase in work intensity in the 1990s (among the lower-paid, in clothing and in the hotel industry); further indirect evidence of increases in work intensity is suggested by the increasing figures for workplace-related illnesses. Available evidence is consistent with a hypothesis of work intensification (although more for the 1990s than the 1980s), but it is not especially strong.

The last possibility considered here is that technical progress was of some non-capital-using–labour-saving form after 1982. This could include 'better management': reorganisations of the valorisation (production plus circulation) process that did not involve capital deepening, but were rather concerned with the more efficient management of existing inputs (whether of fixed or variable capital). Green (2006, pp. 69ff) proposes that recent technological change has not been characterised so much by new techniques as by new modes of work organisation that increase the efficiency with which work is brought to the worker and better match the flow of work to the worker's availability. Such 'effort-biased technological change' increases the productivity of those workers who can commit to high effort levels (whether through persuasion or compulsion). While characteristic of the techniques introduced by the ICT revolution, it also includes 'just-in-time' methods of inventory control, 'total quality management', 'quality circles', team-working, flexible production systems and multi-skilling, and functional flexibility in service industries. In all such reorganizations of the work process, the effect of technological change is to require higher effort levels.

'Effort-biased technological change' provides some elements of an explanation of why there was a continuing increase in labour productivity in the absence of capital deepening, and is consistent with the changing balance of class power. The decisive shift in this balance towards capital at the end of the 1970s was accompanied by stagnating real wages, real declines in the minimum wage, a continuing fall in union coverage, and an ideological offensive, both denigrating all formal and informal institutions of the working class and celebrating a culture of individualism and financial gain. In such an environment, technological change that focuses on bringing more work to the compliant and the subordinated is at least consistent with the overall picture. But more work is required in investigating the details.

6. Conclusion

From the perspective of profitability, the development of the US economy in the last third of the twentieth century divides into two distinct and quite different periods: 1964–82 and 1982–97. Whereas Mohun (2006) concentrated on the relation between profitability, productivity and the real wage, this paper has concentrated on the relation between profitability and technical change via the evolution of capital productivity in the US economy from 1964 to 2001. While the overall pattern of its movement is broadly the same as found in earlier studies (minor differences being due to different choices of definitions and coverage), this paper has considered how the classical categories of productive and unproductive labour and capital can be used in its analysis; and has proposed a detailed decomposition of capital productivity.

The main results can be summarised as follows.

(1) In both earlier and later periods, the major driver of change is 'real capital productivity', the ratio of labour productivity to the 'technical composition of capital' (understood as a constant price measure of net fixed assets per hour).
(2) The first period, 1964–1982, has some elements of a classical period *à la Marx*. Capital productivity fell steeply because a rising technical composition of capital could only generate rising labour productivity at a lower rate (and the rate of surplus value was constant). Hence the rate of profit more than halved, being driven down by falling capital productivity [and the rising wage share of unproductive labour discussed by Mohun (2006)]. Falling capital productivity was thus an expression of the increasing difficulty of extracting labour productivity increases through capital deepening.
(3) The second period, 1982–97, is quite different. Following a continued stalemate in class struggle in the 1970s, the remainder of the century saw a sustained and successful offensive by capital (signified politically by the election of a Republican President and the frontal assault on organised (and unorganised) labour, and pre-figured by the change in Federal Reserve interest rate policy). The technical composition of capital was roughly constant, but labour productivity was rising so that real capital productivity rose sharply, driving up the rate of profit [in spite of the extraordinary increase in the labour income of supervisory labour explored by Mohun (2006)].

The main interest for a macroeconomics inspired by the Marxian tradition concerns the exceptionalism of this later period, that is, the explanation of sustained annual increases in labour productivity in the absence of capital deepening. The shape of the graphs in Figure 5 suggest strongly that it is implausible to attribute this exceptionalism to measurement error (either in the measurement of the quality of net fixed assets or in the measurement of labour quality). Consequently, it must be due to some sort of reorganisation of the labour process (such as bringing work more efficiently to workers) that extracted labour productivity increases without capital deepening. This suggests the necessity of a more detailed disaggregated investigation of labour processes in order to understand better the decisive change in the balance of class forces that occurred at the end of the 1970s and its effects on the pattern of technical progress.

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Appendix

All data are from the National Income and Product Accounts (NIPA) unless otherwise specified and are available at http://www.bea.gov/ (the version used dates from August 2002).

A.1. The measurement of net output

Net output: current dollars

In order to create a measure of money value added in current dollars, the following are subtracted from net domestic product (NDP): compensation of general government employees (B568RC0B&C plus B251RC0B&C, T.6.2B&C rows 78 and 83); imputations for GDP (A191RC; T8.21, line 171).

The following adjustments are then made:

(1) Because compensation of general government employees is not included in money value added, rows 144 (standard clothing issues to military personnel) and 147 (contributions for social insurance for Federal Government employees for certain programs) of table 8.21 are not included in the imputations figure. The other employment-related imputations were all multiplied by the ratio of total compensation of all employees (A4002C0B&C T.6.2B&C, line 2) less compensation of general government, to total compensation of all employees.
(2) Because consumption of fixed capital is not included in NDP, rows 133 and 153 of table 8.21, which both relate to the consumption of fixed capital, are excluded from imputations.
(3) Line 125 of table 8.21 (owner-occupied housing, consumption of fixed capital) is added to NDP, so that it is not subtracted twice.

Net output: chained 1996 dollars

An implicit price deflator for NDP is constructed as the ratio of NDP at current prices (A362RC; T.1.9, line 29) to NDP at chained 1996 dollars (A362RX; T.1.10, line 13). This is denoted as $P(MVA)$ in the text.

A.2. The measurement of wages and hours of productive and unproductive labour

Total wages

A labour income is imputed to the self-employed in each industry as the average labour compensation per full-time equivalent employee in that industry. This is added to the NIPA compensation of employees by industry.

Productive and unproductive industries

Productive industries are: Agriculture, Forestry and Fisheries; Mining; Construction; Manufacturing; Transportation and Public Utilities; Retail Trade (Eating and Drinking Places); Hotels and Other Lodging Places; Personal Services; Business Services (Disinfecting and Pest Control, Building Maintenance, Computer and Data Processing, Photofinishing Laboratories); Auto Repair, Services and Parking; Miscellaneous Repair Services; Motion Pictures; Amusement and Recreation Services; Health Services; Educational Services; Social Services and Membership Organisations; Miscellaneous Professional Services (1972 SIC)/Other Services (1987 SIC) (Engineering and Architectural Services, and Research and Testing Services except those of Non-Commercial Research Organisations); Government Enterprises. Unproductive Industries are: Wholesale Trade; Retail Trade (except Eating and Drinking Places); Finance, Insurance and Real Estate; Business Services (other than those listed as productive); Legal Services; Miscellaneous Professional Services/Other Services (other than those listed as productive); Private Households and General Government.

Productive labour in productive industries, and its wages earned, is determined by mapping the BLS category of 'production worker', her wages and her hours into NIPA data. An approximation procedure for individual services is constructed using Total Services data. There are no relevant BLS data for Transportation and Public Utilities, and Total Services prior to 1964; this determines the starting date of all the series of this paper. Unproductive labour in productive industries, and its wages earned, is determined by subtraction from the industry totals. Unproductive industries employ no productive labour. Because of the SIC change, there is a break in the data between 1986 and 1987, but at the level of aggregation of this paper this is not important. The change between the 1987 SIC and the NAICS is more dramatic, and determines the end date of 2001 for all the series of this paper. The general methodology of calculation is presented by Mohun (2005).

A.3. The measurement of the capital stock

The capital stock is the sum of net fixed assets and inventories. The paper makes the major simplifying assumption that only production workers work with any capital stock.

Net fixed assets: current replacement cost

The fixed asset tables (FAT) are on the BEA website (the version used was posted in September 2002). Note that all industries are classified according to the 1987 SIC, which creates potential problems with the pre-1987 employment and wages data, but not at the level of aggregation used here. Data are for year-end net fixed assets.

The current price data by industry is in table 3.1ES; table 5.1 gives the stock of owner occupied (line 15) and tenant-occupied (line 18) housing in Agriculture; table 7.1 (line 57) gives the stock of fixed assets of Government Enterprises.

Net fixed assets: chained 1996 dollars

Quantity indices are given in tables 3.2ES, 5.2 and 7.2, and applying these to the 1996 figures in each industry gives net fixed asset figures at chained 1996 dollars. Productive and unproductive capital are defined by the productive and unproductive industries listed above. Net fixed assets for the Eating and Drinking Places component of Retail Trade, and the productive components of Business Services, are derived as the proportion of production workers in the component to all production workers in the industry. Similarly, Other Services in the Fixed Assets Tables are divided between the NIPA Social Services and Membership Organisations, and the productive components of Other Services in the same way.

Because the figures are chained, the constituent industry components do not sum to the total. But the difference is not large. Summing across all private industries, and comparing with the BEA aggregate for all private industries, the 1964 sum is 0.92% higher than the 1964 aggregate (some US$59 billion, falling steadily to 0 in 1996 and then rising to 0.065% in 2001. At the level of aggregation with which this paper deals, I have assumed that this does not matter.

The price of net fixed assets

The ratio of net fixed assets at current replacement cost to net fixed assets in chained 1996 dollars determines the implicit deflator for net fixed assets.

Inventories: current replacement cost

Inventories are in the Federal Reserve's Flow of Funds Accounts posted on the web in September 2002 and can be found at http://www.federalreserve.gov/releases/Z1/Current/data.htm. Inventories in Nonfarm Nonfinancial Corporate Business are in table B102, line 5, and in Nonfarm Noncorporate Business in table B103, line 9. They are allocated to productive and unproductive sectors in the following way. Assume the only productive industries with inventories are Mining, Construction, Manufacturing, Eating and Drinking Places in Retail Trade and Government Enterprises, and the only unproductive industries with inventories are Wholesale Trade, and the rest of Retail Trade. Then inventories are allocated proportionally, using the BEA's Gross Product Originating data (posted in November 2002, with the productive and unproductive components of Retail Trade determined by production labour proportions). This is evidently approximate.

Inventories: chained 1996 dollars

As with money value added, the implicit deflator for NDP is used.

Capacity utilisation

The Federal Reserve Board.s measures of capacity utilisation are available at http://www.federalreserve.gov/. The series are G17/CAPUTL/CAPUTL.B50001.A for the whole economy (from 1967), and G17/CAPUTL/CAPUTL.B00004.A for Manufacturing (from 1948). For this study, the 1966 figure was constructed by taking the ratio for 1967 of the index for the whole economy to the index for Manufacturing, and multiplying by the 1966 figure for Manufacturing, and then likewise working backwards to 1964.