

Measurement or Management?: Revisiting the Productivity Paradox of Information Technology

By Stuart Macdonald*, Pat Anderson**, Dieter Kimbel***

Summary

In 1999, the Department of Trade and Industry in London commissioned a literature review of, and commentary on, the productivity paradox in information technology. This paper is derived from that report. The authors find that the discussion of the productivity paradox took place largely in the United States and particularly in Massachusetts. Two quite separate strands were evident: the literature of the economists, seeking ever-better methods of measurement, and that of management authors, seeking ever-better methods of management. This paper gives more attention to the latter than is customary, and concludes that the link between management methods and the requirements of IT may be closer than has hitherto been suspected. A combination of factors rather than a single factor is probably responsible for the disappointing productivity of IT. Within this combination, the problems that IT posed managers and the opportunities it offered management consultants are especially intriguing.

1. Introduction

The information technology (IT) productivity paradox is the perceived discrepancy between IT investment and IT performance, between input and output. The particular perception which launched public discussion of the issue can be dated, with some precision, to a book review by Robert Solow published in the *New York Times* in July 1987 which included the line, “we see the computer age everywhere except in the productivity statistics” (Solow, 1987). From mighty aphorisms little aphorisms grow and other sages readily declared on the issue, Lester Thorow, for example, announcing that “The American factory works, the American office doesn’t” and Paul Strassman that “There is no relation between spending for computers, profits and productivity.” The topic suited the requirements of the business press perfectly, allowing businessmen to share concern about a common experience. And fuelling the interest of the business press were the management consultants. Predating Solow by some months is the work of Stephen Roach, a consultant working for Morgan Stanley, who was also to figure prominently in the later discussion. It was Roach’s work on IT productivity in the service sector which attracted Eric Brynjolfsson and Lorin Hitt to the topic, and probably many other economists. Strange, then, that a single core should produce such divergence in approach to the subject.

The justification for investment in IT was simply that it would increase productivity. The assertion that this was not necessarily the case reduced confidence in IT rather than investment in IT. Managers had no option but to invest in IT; without IT their firms went out of business. Understanding just what IT does in the organisation was clearly vital to resolving the IT productivity paradox. Yet neither of the major approaches taken to the problem shed much light on this central issue. One, that taken by the economists, concentrated almost exclusively on finding better means of measuring productivity: the other focused on the better management of IT. Neither paid much attention to the other, and neither resolved the productivity paradox to anything like general satisfaction. This paper considers the two approaches and what insights have been hidden by their separation.

* Management School, University of Sheffield, 9 Mappin Street, Sheffield S1 4DT, England, Tel/Fax: +44 (0) 1993 772871, email: S.Macdonald@Sheffield.ac.uk

** Management School, University of Sheffield, 9 Mappin Street, Sheffield S1 4DT, England, Tel/Fax: +44 (0) 1993 772871, email: Patricia.Anderson@Sheffield.ac.uk

*** Dieter Kimbel & Associates, Jakob Latscha Str. 4, 63-303 Dreieich, Germany, Tel/Fax: 00 331 4601 7931, email: dkimbel@noos.fr

2. Meaning and Context

The meaning of productivity and of IT would seem obvious enough, but the more the terms were used in the context of the productivity paradox, the less clear they became. Productivity in its crudest, and most common, form is labour productivity — the level of output divided by labour input. More sophisticated is multifactor productivity (ambitiously called ‘total factor’ productivity), which is the level of output for a given level of several inputs, typically labour, capital and materials (Brynjolfsson, 1993). This provides a better guide to efficiency because it adjusts to shifts among inputs, but the data are difficult to acquire. Thus, at the most basic level, discussion about the productivity paradox was torn between a measure of productivity that was preferable but hard to obtain, and a measure that was less satisfactory, but much easier to obtain.

The water was further muddled by the baggage IT had accumulated before Solow’s declaration. Throughout the late 1970s and early 1980s, the fear was widespread that IT would replace workers — so many secretaries out for every word processor in — (e.g., Windschuttle, 1979), an alarm which seemed to make labour productivity from IT a more apposite measure than total factor productivity. Consequently, interest in labour productivity was directed more towards measuring the impact of reductions in labour input than towards the problems of measuring output with any accuracy. Only when the focus turned to measuring output did it begin to become clear how difficult measurement would be, and indeed how awkward were concepts of productivity designed for the manufacturing sector when transferred to the service sector.

The result was that inordinate effort was put into issues of definition and measurement in addressing the productivity paradox. Economists busied themselves with ever more detailed calculations, and sophisticated justifications of calculations, of IT productivity. The gulf between this esoteric enthusiasm and the approach of the business press yawned. More important, it sucked in and suffocated those who might have applied other perspectives to the paradox. Sometimes the discussion became surreal with definitions of IT abandoning common sense altogether in the determination to follow statistical practice. For example, according to the US Bureau of Economic Analysis (PEA), IT was only ‘Office, Computing and Accounting Machinery’. This definition discouraged many researchers from including even the categories of communications equipment, instruments, photocopiers and related equipment and software and related services in their calculations of IT productivity.

“And how long must users of government statistics put up with the total lack of any PPI [producer price index] for the single most important component of PDE [producers’ durable equipment], communications equipment, when the PPI contains literally hundreds of detailed commodity

indexes for nuts, bolts, pipes, flanges, valves, cans, barrels, pails, tanks, hinges, cleats, knives, and other crude products of lesser economic importance?” (Baily and Gordon, 1988, p. 420)

It is important to consider the context in which discussion of the productivity paradox was set in the second half of the 1980s, a consideration which perhaps requires a hindsight that contemporary authors were unable to supply. The productivity paradox was set firmly in the context of a productivity slowdown which had afflicted the developed economies since the early 1970s:

“... the average growth in total factor productivity (labour productivity) for 18 OECD countries fell from 3.25% (4.41%) per year over the years 1961–1973 to 1.09% (1.81%) per year over the years 1974–1992. Why has the productivity slowdown persisted for so long in spite of large absolute increases in research and development, scientific knowledge and technological innovations? This seems to be the essence of the productivity paradox.” (Diewert and Fox, 1997, p. 3)

The situation was no different in the United States (Brynjolfsson and Hitt, 1988), but the expectation that it should be otherwise was very much greater than elsewhere. IT, or more precisely, its manufacturers, promised rapid recovery from slowdown. Thus, when the general productivity slowdown of the early 1970s coincided with a very rapid increase in the use of IT, there was understandable expectation that the latter would eradicate the former. These expectations were further fuelled by hype, much of it from the IT industry, about the brave new world of the Information Age. Governments, too, contributed to the enthusiasm with policies based on high technology, designed to convert just about anywhere into a bustling Silicon Valley. The Luddism of the 1970s had become outmoded by the early 1980s: new technology would provide new and high-quality employment, new competitiveness and new prosperity. And at the heart of all this new technology was IT.

There seemed to be only one obstacle to IT overcoming the productivity slowdown, and this was simple lack of information capital. An issue prominent in the early 1980s was the discrepancy between capital per information worker and capital per production worker. Information workers, it was argued, were deprived of the level of capital which assisted manufacturing workers and would become more productive with more capital to support them, though not necessarily IT (Strassman, 1985). With growth in the numbers of information workers came a steady increase in their production capital until it eventually equalled that of blue collar workers.

“Investment in computers at current prices increased at twenty-seven percent per year from 1958 to 1989, while current price GDP expanded at only 7.9 percent and investment at 8.1 percent. During this period average annual

inflation rates for GDP and investment have been 4.4 and 3.7 percent, respectively, *while computer prices have declined at an annual rate of 19.8 percent!* [italics in original] (Jorgenson and Stiroh, 1993. See also Gordon, 1987, p. 1)

But no matter how many more information workers, no matter how much more was spent on IT, and no matter how cheap and how powerful computers became, nothing seemed to have any influence on a productivity paradox that, by the late 1980s, simply could not be ignored. Indeed, particularly galling was the observation that, in as much as there was any recovery in productivity growth in the 1980s, it was in the manufacturing sector rather than the service sector with its much greater investment in IT (Baily and Gordon, 1988). How appropriate, then, that Solow's quip should have appeared in his review of Cohen and Zysman, *Manufacturing Matters: The Myth of the Post-Industrial Economy*.

3. The Paradox Unfolds

It is not the case that the productivity paradox started in 1987 because Solow declared that he had noticed it, and ended in 1991 because Brynjolfsson and Hitt declared it had ended. This is merely the period in which public discussion of the paradox was most intense. The development of the discussion was gradual, it progressed in stages, and it is not over yet.

Stage 1 — In the beginning, because IT was imagined to displace labour, there was great interest in labour productivity and IT, leading to an almost automatic assumption that labour productivity was the appropriate measure of IT impact. There were many studies of clerical employee displacement, and a huge gulf opened between advocates of IT and detractors with little research to help span the chasm (Mandeville and Macdonald, 1980).

"IBM, for example, instructed its sales employees to ask potential customers what productivity increases they sought, and trained its sales workers to prepare specific projections of the productivity gains to be anticipated. These figures were completely speculative, as old IBMers freely admit. No one really knew what productivity effects would occur, and no one, least of all the computer manufacturers, was funding researchers to carefully measure the outcomes of computerization on clerical productivity levels within individual firms." (Attewell, 1993, p. 2)

Stage II — By the late 1970s, occasional hints were appearing in a diverse literature that IT performance was less than expected. Even so, computer budgets were huge and growing.

"... companies were on a treadmill. As their competitors provided services that could only be offered using IT, firms found they had to invest more and more in IT just to stay in the game, whether or not there was a clear ROI

[return on investment] for those investments." (Attewell, 1993, p. 3)

Indeed, return on investment was just about the most sophisticated tool firms employed for evaluation of IT investment, when they used any at all. So essential was IT reckoned to be that many firms never bothered with evaluation. A variety of techniques is now available, but they are seldom used (Farbet, Land and Targett, 1992).

Stage III— In the early 1980s, it seemed a mistake to think of IT in terms of productivity. IT was to be used for grander purpose altogether, for strategy (Cash and Konsynsk, 1985). Great emphasis was given to case studies where strategic use of IT had produced massive competitive advantage (Wiseman and Macmillan, 1984-5), those of American Airlines (Monteiro and Macdonald), American Hospital Supplies, and Citibank becoming classics in their time. It was important to think of IT in radically new terms. After all, as the business press of the period never tired of reminding the world, if the automobile industry had done what the computer industry has done, a Rolls-Royce would cost \$2.50 and get 2,000,000 miles to the gallon. A variant was that if progress in the rest of the economy had matched progress in the computer sector, a Cadillac would cost \$4.98, while ten minutes' labour would buy a year's worth of groceries.

Stage IV — By the late 1980s it was clear that much IT investment had found its way into management information systems (MIS) (basically surveillance and control systems), where it could not be expected to be directly productive. At the same time, growing public alarm, fuelled largely by the business press, led to exploration of a host of possible explanations for the paradox. Individually, none was convincing and collectively they were confusing. While the economists explored, the business press, IT companies and governments tended to point to specific firms as examples of the 'successful introduction' of IT, examples that other firms were encouraged to follow.

Stage V — Since the late 1980s, much IT investment has been channelled into telecommunications. Therefore, it is argued, expectations of productivity increase are unrealistic. The paradox is not so much resolved as in abeyance (*Economist*, 2000).

Nearly all discussion of the productivity paradox focuses on the reasons for its existence. Eric Brynjolfsson, one of the leading figures in the discussion, has conveniently isolated just four of these reasons (Brynjolfsson, 1993):

- 1) mismeasurement of outputs and inputs — outputs and inputs of information-using industries are not being properly measured by conventional approaches
- 2) lags caused by the need for learning and adjustment — time lags in receiving the pay-offs to IT make

analysis of current costs versus current benefits misleading

- 3) redistribution and dissipation of profits — IT is especially likely to be used in redistributive activities among firms, making it privately beneficial without adding to total output
- 4) mismanagement of IT — lack of explicit measures of the value of information makes information particularly vulnerable to misallocation and over-consumption by managers.

Any one of these would have fed discussion for decades. In fact, there is rather more to the explanation than these four: certainly there are more explanations, but the explanations are also inter-related and intermingled. This has not deterred individual commentators from taking the simple approach and isolating individual explanations. Those who have seized upon the mismeasurement explanation are most guilty of this simplification.

4. Measure

So absorbing was the challenge of finding better measurements for IT productivity that many of those who accepted seemed to forget that measuring productivity was merely a means to an end and not the end in itself. The very problems of measurement stimulated something of a productivity paradox industry (Diewert and Fox, 1997), the productivity of which was itself questionable. Many economists, and especially econometricians, became besotted by the problems of measuring the productivity of IT (Stoneman and Francis, 1994). Most concentrated on the almost intractable problems of measuring output, but some were equally content to examine the problems of measuring input (Baru and Lee, 1997). Input, it might be imagined, should have been easy enough to calculate, but it was not. The quality of inputs varied, including the quality of labour, and far more employees were involved with IT than were conventionally counted; often only those who manned central IT help desks were deemed to be IT workers. In one of the few pieces of British research on the productivity paradox, Paul Stoneman advised the Central Statistical Office to adopt hedonic pricing for computers, which would at least relate price to quality:

“The hedonic analysis shows that the retail price of an average, constant quality, microcomputer fell by around £1430 over the six and a half year period from December 1986 to May 1992 representing a price reduction of 70%.” (Stoneman, Bosworth, Leech and McCausland, 1992, p. i)

As hardware costs became unbundled from software costs and then dwarfed by these software costs, IT inputs became increasingly hard to measure. The difficulties resulted in software costs often not being measured at all.

In addition, more and more IT costs were being incurred outside the central IT budget of organisations.

“My best guess — and it is only that — is that the IT hardware investment data obtained from a central MIS manager is [sic] one-half to one-third of the firm’s ‘true’ investment in IT.” (Attewell, 1993, p. 11)

The reliability of input measures was critical not only because these measures had to be compared with output, but because, at least in the United States, they often substituted for output. The US Department of Commerce (unlike statistical authorities in Western European countries and Japan) made no attempt to measure productivity in the finance sector, for example, but simply assumed that output was equal to input labour. Consequently, the US finance sector could never have more than zero productivity.

“Given that knowledge work is fundamentally different from manual work, a redefinition of productivity for knowledge work intensive industries would be a useful endeavor.” (Davis, Collins, Eierman and Nance, 1993, pp. 339-40)

But even if input could be measured, it seemed that the output would prove somewhat trickier to measure.

“Not surprisingly, when you can easily count the costs of computer investment but have a difficulty assessing the benefits, particularly those that take time to be realised, IT can look like a bad investment.” (Brynjolfsson and Hitt, 1998, p. 4)

The sorts of unmeasured benefits generated by IT include product development cycle time, customer convenience, wider consumer choice, quality control, production and distribution of knowledge, and increased industry efficiency. It had been, if not exactly easy, at least easier, to measure outputs in the past because they were largely the countable outputs of manufacturing industry. But the nature of the economy had been changing and a rapidly growing proportion of its outputs was coming from the expanding service sector. Indeed, the value of even manufacturing output depended increasingly on such intangible factors as quality, timeliness, variety, and so on. If computers were still not actually everywhere, as Solow had suggested, they certainly proliferated in those areas (banking, insurance, business services) where productivity was hardest to measure. And if measuring productivity from IT in manufacturing was difficult, measuring it in the service sector was virtually impossible.

“... the term *productivity* is an artifact that reflects a workplace characterized by the transformation of tangible materials, via visible manual efforts, into measurable products.” (Davis, Collins, Eierman and Nance, 1993, p. 339)

“The irony is that while we have more raw data today on all sorts of inputs and outputs than ever before, productiv-

ity in the information economy has proven harder to measure than it ever was in the industrial economy.” (Brynjolfsson and Hitt, 1998)

In fact, so dominant was the ability to measure productivity in manufacturing that for a long time it seemed that the main influence of computers on the economy’s productivity came from the sector making them, rather than from sectors using them.

“While the impact of information technologies such as computer equipment on the productivity of sectors *using* this equipment is not readily observable, the productivity originating from the sector *producing* computer equipment is evident. In Germany, Japan and the United States, the computer sector has been the driving force behind manufacturing productivity gains in the 1980s. Nowhere is this more apparent than in the United States, where the computer sector has been estimated to have contributed fully two-thirds of the post 1979 rebound in manufacturing productivity growth.” [emphasis in original] (Wyckoff, 1993, p. 2)

It was at this point in the progression of the discussion that the economists chose not to delve deeper into the dynamics of the information economy, nor to follow where information economics led to explore the mysteries of information itself. Instead, workman-like, they blamed the data.

“Much of the productivity shortfall of the 1980s was a mirage anyway. Our tools for measuring productivity — designed for counting bushels of wheat and Model Ts off Ford’s assembly line — are blunt when called upon to measure the tremendous improvements in service, quality, convenience, variety and timeliness. This is especially true in the service sector, where output data is unreliable and things that can’t be measured are assumed not to exist.” (Bakos and de Jager, 1995, p. 128)

The data were poor, the economists claimed, not only because of conceptual difficulties, but because they were badly gathered.

“The problem then, is that the commercially-available data on firm level IT investment is dramatically undercounted, due to cheap survey methods which contact one person in a massive corporation. Academic or government surveys could do much better, but they have never been done.” (Attewell, 1993, p. 12)

The inadequacy of data at the national and sectoral levels encouraged the use of the apparently superior data from samples of firms. If these data showed productivity growth, then clearly other data from other levels of investigation were inadequate.

“The closer one examines the data behind the studies of IT performance, the more it looks like mismeasurement is at the core of the ‘productivity paradox’.” (Brynjolfsson, 1993, p. 14)

So, the economists’ answer to the problem was to find the right data (Schreyer, 1998). Paul Strassman’s calculations of what he calls his ‘Information Productivity Index’ are one example of just what processing the data were, and still are, expected to endure.

“For output, I use Stern, Stewart & Co.’s popular Economic Value-Added (EVA). If EVA is not available, output can be calculated by subtracting from operating profit after taxes the value of shareholder equity, multiplied by the cost of capital. The costs of sales, general and administration (SG&A) are a reasonable approximation of managerial costs. Divide EVA by SG&A to get the Information Productivity Index.” (Strassman, 1994, p. 45)

Somehow, the Information Productivity Index seems to miss the point. The productivity paradox had less to do with equations and data than with concepts and even faith. There were those who questioned whether productivity should be measured at all. The economists were not among their number; the economists were having a thoroughly busy and jolly time with their measurements.

If firms could not be relied upon to reap productivity benefits from their investments in IT, and productivity increases at the firm level might well be hidden at the industry or sector level, then the level at which the impact of IT on productivity was sought was clearly crucial. The productivity paradox, it seemed, was a consequence of searching at the wrong level. National productivity statistics were generally awful (Ralston, 1998), but statistics could also be unreliable at the industry level, especially when output and productivity are inferred from national input/output tables (Attewell, 1993). Productivity gains could often be detected at the level of the individual unit, or even the individual person, but they would disappear at the firm level. A sample of firms seemed to offer the best prospect of finding productivity increases attributable to IT, but where to find a suitable sample?

“In my judgment, the greatest prospect for assessing the impact of IT investment lies in studies of productivity based on representative samples of firms. I am skeptical of the value of more aggregate-level studies which use government data ... The greatest problem is not the measurement of firm-level productivity but in obtaining accurate data on IT investment at the firm level.” (Attewell, 1993, pp. 10–11)

This was precisely the approach which eventually allowed Brynjolfsson and Hitt to declare the paradox resolved, but they were always open to the accusation that their sample, consisting entirely of large firms, had not been representative of firms as a whole.

The last resort of many of those determined to find productivity increases from IT, once the what, the how and the where of IT had been declared inappropriate for measurement, was the when. The argument was simple: there

might not be any productivity gains from IT right now, but they would occur in time. Sometimes the argument focussed on firms; they would become better at using IT as they learnt from experience (Johannessen, Olaisen and Olsen, 1999): sometimes the learning was expected from economists themselves as they gained experience in searching out productivity from IT. Perhaps this is why the eventual declaration by Brynjolfsson and Hitt suggested a certain inevitability. The hunt was over.

"We conclude that the productivity paradox disappeared by 1991, at least in our sample of firms." (Brynjolfsson and Hitt, 1996, p. 541. See also Brynjolfsson and Hitt, 1993)

Equally predictable was the sudden rush of findings which confirmed those of Brynjolfsson and Hitt (Dewan and Min, 1997). By 1997, Brynjolfsson and Hitt had explored a variety of other data to produce productivity figures for 600 firms between 1987 and 1994. They found that the productivity increase was greatest for those firms which had invested most in IT and which had used IT longest (Brynjolfsson and Hitt, 1997). Others, however, are suspicious of this conclusiveness and find these results just a mite too convenient.

"As to estimates by Brynjolfsson and Hitt that computers earn returns of 24 to 57 percent ... what friction of market failure prevented these firms from investing even more in computers until the returns were driven down to those on other types of capital?" (Gordon, 1994, p. 326)

And while he was quite willing to admit that the situation may have improved since his own dismal assessment of computer productivity, Roach considered Brynjolfsson's estimates of 81% gross annual return on IT investment for manufacturing and service companies together far too large (*Economist*, 1994).

Brynjolfsson's explanation for the end of the productivity paradox includes an expectation that there would be some lag before benefits would be realised; the transition to the Information Age would obviously take time (Brynjolfsson, 1993). Many economists agreed that they would have to wait to see the end of the productivity paradox. Indeed, so dedicated was this waiting that Jorgenson and Stiroh have referred to "a kind of Computer Cargo Cult among economists and economic historians, patiently awaiting a deluge of spillovers like those that supposedly accompanied earlier technological revolutions" (Jorgenson and Stiroh, 1999). However, Brynjolfsson had in mind a productivity lag of just two or three years (Brynjolfsson, Malone, Gurbaxani and Kambil, 1994), which suggests a decided lack of patience, certainly compared with that envisaged by Paul David. David likened the computer to the dynamo and considered that IT would take as long to make an economic impact as electricity had done — perhaps four decades or so (David, 1990). Not everyone thought his analogy sound. Jack Triplett and Robert Gordon found it totally unconvincing:

"We have reached the fortieth anniversary of the commercial computer. The price of computing power is now less than one-half of one-tenth of 1 percent (0.0005) of what it was at its introduction. No remotely comparable price decreases accompanied the introduction of electricity." (Triplett and Gordon, 1994, p. 322)

There were lots of other innovations of the late nineteenth and early twentieth centuries, they argued — chemicals and plastics, motor cars, household appliances, highways, supermarkets. Computers were just not in the same league. There was some support for their stance.

"... the puzzle about computer hardware in the 1980s was more apparent than real. To restate Solow's quip, computers were not in the productivity statistics because, it turns out, computers were not everywhere. Recall that in 1993 computer and peripheral equipment accounted for just 2 percent of the nominal net stock of business capital in the United States. By way of historical comparison, in 1890 railroads accounted for about 18 percent of this stock. Clearly computers have a long way to go before they become as widespread as railroads in the nineteenth century." (Oliner and Sichel, 1994, p314)

But David's main contribution to the discussion was not in the detail; he added an intellectual dimension which the discussion has sorely needed ever since its inception. For example, as Romer noted, IT investment was just too small a portion of total investment to have any but a tiny impact on the productivity statistics.

"'What have all those computers been doing?' or, more prosaically, 'Why has the vast increase in investment in computer power not been reflected in higher measured productivity growth?' It seems to me that there is no mystery here at all ... Since computers are a quite small part of total investment, a vast increase in investment in computers would yield only a small increase in measured output even if all the computers were being used productively and were generating measured output." (Romer, 1988, p. 427. See also Diewert and Fox, 1997)

That was in 1988, by which time the discussion of the productivity paradox had already acquired its own momentum and its own agenda. Romer was ignored. David himself argued that his analogy not be taken too far. Towards the end of a seminal paper, he emphasised the fundamental importance of the awkward characteristics of information. Information, he reminded those econometricians who expect their data to be aligned in neat rows, is just not like other goods (David, 1990).

5. ... or not to Measure

One objection to focusing on IT productivity is that while productivity is measured in terms of things being counted

(number of employees, pounds of nails, and so on), IT investment is made to produce things that are not easily counted (such as quality and customer service) (Brynjolfsson and Hitt, 1998). Productivity, it was asserted, was not the right measure of IT performance, and could not capture its full impact. And perhaps policymakers and strategists did imbue productivity with too much importance from the late 1970s. Given its role in combating inflation, in wage bargaining and in social welfare (and also in the measuring of international competitiveness at the industry and plant level), this would have been understandable (Agrawal, Findley *et al.*, 1996. See also Attewell, 1993). This does not mean that productivity should be the only measure of IT performance, and certainly not that productivity should mean simply labour productivity.

There are, of course, other measures of performance than productivity, but they tend to be the sort of financial measures beloved by accountants, such as return on investment, return on assets, and earnings per share. Strassman (1997) may have valued such measures at the micro level, but most other authors considered them even more flawed in measuring the performance of IT than productivity measures (e.g., Johannessen, Olaisen and Olsen, 1999). Kaplan (1989) argued that existing accounting systems were totally inappropriate, not just for coping with IT, but for coping with any new technology. The productivity paradox simply demonstrated that accounting systems were decades out of date. Interestingly, accountants seem to have had the sense to steer well clear of the productivity paradox debate (Son, 1990).

What are really required, of course, are operational measures (Johannessen, Olaisen and Olsen, 1999), and there has been some consideration of what might be required to measure customer satisfaction (Ellis and Curtis, 1995; Hurley and Laitamaki, 1995), customer loyalty (Reichheld, 1993), employee satisfaction through teamwork (Henderson, 1994; Lumkin and Dess, 1996; Schrednick, Schutt and Weiss, 1992), product quality (Feigenbaum, 1985; Garvin, 1987; Teas, 1993), and service quality (see Freeman and Dart, 1993; Kordupleski, Rust and Zahorik, 1993; Quinn and Humble, 1993). The US National Research Council (1994) published a report into the use of IT in the service sector; it too found that conventional measurements of productivity were woefully inadequate. The report's chief conclusions were that the outputs of many service industries are hard to define, that for many key service industries (for instance, banking, education, health care and government) outputs are actually measured by inputs, that the effects of new services and quality improvements are rarely well captured, and that competition often robs the investing industry of the productivity benefits of its IT investments, forcing it to pass them along to customer industries (Quinn and Baily, 1994). This last point is important. The economists saw

the problem as a failure of those who invested in IT to appropriate the benefits.

"Although IT offered customers much higher quality, variety, convenience, reliability, and accuracy, service companies found it hard to capture these benefits in enhanced margins or measured output per person employed ... In industry after industry, information technology became essential to survival or growth and resulted in demonstrably enhanced convenience and value to customers — often without showing either definable increases in industrywide financial returns or measurable productivity increases." (Quinn and Baily, 1994, pp. 38–9)

Another perspective might have suggested that something more fundamental was afoot than mere evasion of productivity indicators. IT, it would seem, was making a more basic contribution to the economy and to the performance of organisations than improved productivity. IT investment, it was argued, could not be expected to produce direct benefits, however measured. There would be benefits, but they would be indirect and long-term. They would be enabling, much like those from investment in electricity or the steam engine (Brynjolfsson and Hitt, 1998). It was a waste of time trying to measure the benefit from what was basically an improvement in infrastructure.

"The managerial decision for IT infrastructures is generally not *whether* to invest in IT, but rather how to obtain needed compatibilities at lowest cost ... several firms noted that the only truly rigorous way of evaluating many infrastructure payoffs would be to calculate the opportunity cost of 'not being in that business'; i.e., the total business loss that would have been incurred if the investment had not been made." [emphasis in original] (Quinn and Baily, 1994, p. 34. See also Banaghan, 1996)

The argument was basically that IT was essential just to remain in business. But how much IT? What was the appropriate level of investment? Organisations were quite capable of spending all they had on IT, and IT producers of letting them. To avoid this sink, senior managers became more and more attracted to contracting out much of their IT. That way, they could pay for precisely and only the services they required.

"IT infrastructure is ... probably the most difficult IT investment to justify in advance and then to measure the resulting impact ... IT infrastructure has a large momentum requiring, seemingly, ever increasing resources. The costs of significant changes to infrastructure are high and well beyond the cost of the purchases and the associated information systems personnel ... Outsourcing is seen by some senior managers as a way to off-load these ever increasing costs of infrastructure." (Weill, 1993, p. 571)

Whether it is argued that the benefits of IT would be subsumed by profligate IT expenditure were it not for contracting out, or that IT, by reducing the costs of coordina-

tion both inside and outside the organisation, makes contracting out possible (Malone and Rockart, 1991), it is hard to escape the conclusion that IT is actually more deterministic than has been appreciated. For instance, it seems that the customer-orientation of so much modern management method may be IT-driven in that giving extra value to the customer is one thing that IT seems determined to do despite the best endeavours of companies which have invested in IT to prevent this (Quinn and Baily, 1994).

6. Measurement or Management

The management literature paid little attention to economic explanations of the productivity paradox and offered, not surprisingly, management solutions to the problem. The most obvious blame that could be attached to managers was simply that they had bought the wrong IT. Had they bought the correct IT, there would have been lots of productivity increase. This may be a simplistic view, but then much of the management literature is simplistic, unquestioning and unhelpful. The doyen of management gurus, Michael Porter, was in no doubt about the benefits of IT.

"The question is not whether information technology will have a significant impact on a company's competitive position; rather the question is when and how this impact will strike." (Porter and Millar, 1985, pp 149–60)

Only rarely did this literature consider the possibility of information overload affecting investment decisions for IT, overload made the more likely by the IT itself. More appreciated was that senior managers have often delegated responsibility for IT investment to specialist IT departments. The consequences have been unfortunate:

"... one cannot expect a clear and direct link between IT-investments and productivity. The reason is that the effects of IT are mediated and depend on other factors. Some of these factors can probably be influenced by managerial action. But the managers have chosen not to get involved in the use of IT in their companies but have delegated this responsibility to systems departments. This abdication of responsibility may have resulted in both misdirected IT-investments and in a lack of attempts to find solutions to essential business problems with the help of IT." (Docherty and Stymne, 1993, p. 2)

Under these circumstances, IT investment might be expected to benefit the organisation's IT department rather than the organisation as a whole. The argument could be taken a step further to reach what Pinsonneault and Rivard called the 'Icarus paradox'. This explained the productivity paradox in terms of middle managers devoting more and more of their time to those activities which they can do best with IT (Pinsonneault and Rivard, 1998). They

become increasingly specialised and eschew the traditional generalist strength of the middle manager, a transformation which happens to accommodate rather nicely the downsizing which much management method has recommended for many organisations. Drucker has seen this downsizing as a consequence of IT, but not perhaps in this sense. The mantra of 'what gets measured gets managed' is stronger than ever in these days of management method with the result that management attention is focused on what can be measured most easily and neglects what is less easy to measure. IT has allowed much performance to be quantified very easily — every finger tap at the supermarket checkout — but has trouble with the qualitative (Willcocks and Lester, 1996).

If it is only to be expected, from an understanding of the nature of organisation and the nature of information, that parts of the organisation should exploit IT for their own advantage, it should not be surprising that some parts of the economy do just the same. In so doing, just like individual managers, they may increase their own productivity without affecting the productivity of the whole. When firms use IT to increase market share, they can increase their own productivity while that of their industry remains unchanged. When firms have to invest in IT just to remain in the market, there may be no increase in productivity at any level.

"Other firms will have to adopt the technology to stay in the market. They will not gain market share by doing so, and will nevertheless carry the cost burden of the new investments. The result, viewed across a whole industry, is that costs may increase, and productivity, in terms of revenue per operating dollar, may even decrease." (Attewell, 1993, p. 8)

There are two arguments which stem from this observation: one is that investment in IT has not necessarily permitted the investors to reap the benefits of their investment, that these benefits have been seized by others to the joint frustration of investors and those who would measure productivity increases (Baily and Chakrabarti, 1988). Banking is frequently given as an example: individual banks had to adopt automatic telling machines in order to remain competitive in the industry, but the benefits seem to have been seized by their customers rather than by the banks (though the banks may now be using collusive power to force the return of some of this value).

"... the success in managing the change to CAD, and other [IT] ... would be better served by a greater understanding of its wider implications, e.g. its company-wide benefits, rather than a concentration on a narrow range of benefits confined to the drawing office ... a more strategic awareness of new technology needs to be developed at the apex of the organisation, which is not one solely based on an understanding of simplistic cost-accounting techniques." (Currie, 1989, p418)

But encouraging senior managers in an industry or even in a single firm to think strategically in their acquisition and use of IT is not guaranteed to resolve the productivity paradox either. Such encouragement may discourage them from bothering about productivity effects.

"If such a scenario is correct, one would hypothesize a negative correlation between strategic IT investment and productivity growth, when measured across a sample of firms in one industry." (Attewell, 1993, p. 9)

Moreover, senior managers are probably as reliant as ever on traditional accounting techniques, rather than on IT itself, to discover not only what investment there has been in IT, but what the organisation is doing with it. The other argument stemming from the observation that firms may have to adopt IT just to stay in business is simply that the benefits from IT, including increased productivity, cannot be expected to be universal and must be sought at the right level — individual, department, organisation, sector, economy.

If managers did feel that they had to have IT simply to stay in business, and if they were confused about what sort of IT and how much of it to have, just how logical were their investment decisions? Many of those who discussed the productivity paradox suggested that senior managers may have had very little idea what they were doing. Others insisted that managers should not worry about productivity from IT; they should be content that IT helps them serve their customers (Davis, 1991). Uncertain about the appropriate level of IT investment, it may be that many organisations simply followed the example of others. Basically, they kept up with the Joneses:

"Assess the amount of technology used by other organizations in the same industry. Technology investments should maintain at least threshold levels of IT for the industry." (McKeen and Smith, 1993, p. 444)

While it may be that firms must have computers in order to compete, it may also be that what employees do with computers is almost impossible to manage. Without effective management, computers can easily be used simply to generate work for employee and customer alike.

"A lot of PCs are on the desks in these large corporations because of the corporate decision to standardise on particular versions of technology. But apart from a few dedicated souls who really know how to work them, productivity of the computer's full power is actually very low." (Philip Moodie as quoted in Banaghan, 1996, p. 72)

It is also argued that senior managers soon abandoned their initial attempts to achieve productivity gains in favour of new goals, such as greater market share or greater managerial control. This is what Attewell terms 'goal displacement'.

"... studies of individuals using word processors have noted that instead of using the technology to produce

more documents in a given length of time, employees make five times as many corrections as previously. They also pay more attention to fonts, graphics and so on. In other words, at this individual level, there is a displacement from the goal of increasing throughput productivity to the goal of enhancement of quality and appearance." (Attewell, 1993, p. 4)

It is perhaps easier to see that the goal has been displaced, or rather replaced, than just what the replacement goal might be. It seems that more IT has resulted in more information and more paperwork being processed, and it is widely observed that there is more paper than ever in the paperless office.

"To economists this has a familiar logic. As the unit cost of a good falls, demand for the good increases. Thus even as the unit cost of computer-related work has fallen (due to productivity improvements), the demand for that work within the corporation has increased. With a price elasticity of demand greater than one, the total amount of information processing work after computerization, and its cost, can be greater than the volume and cost of information work prior to computerization. Thus even if the unit cost of doing information work falls dramatically due to computerization, the total demand for such work, and the total cost to the corporation may increase." (Attewell, 1993, pp. 4–5)

Senior managers were often quite unable to control this pointless demand, perhaps because they had never really been sure why they wanted IT in the first place, but perhaps also because they did not really understand what the information part of information technology was all about. It is quite possible to see the productivity paradox as a combination of managerial failure to restrict and direct the resources consumed in the handling of information, and the nature of information. Managers have permitted more work instead of more effective work because they do not understand information.

Most of the leading discussants of the productivity paradox bring the notion of the Information Age somewhere into their pronouncements. A few go somewhat further down this track in acknowledging the fall in blue-collar employment and the rise in white-collar employment (see Freeman and Soete, 1994). The transition has been taking place for decades, but was brought to academic attention only in the early 1970s, originally by Marc Porat (1977). While it was usually clear enough what blue-collar employees did for a living, it was not so obvious what white-collar employees did, and measuring even labour productivity in sectors where there were many of these information workers was no easy matter (Brynjolfsson, 1993). It was all very well to calculate that, armed with IT, one information worker could be substituted for, say, six non-information workers (Lichtenberg, 1993), but it was still not evident what the information worker — the 'white

collar overhead' according to Attewell (1993, p. 5)—actually did.

While information workers were replacing non-information workers, IT — at least according to some authors — was replacing information workers (Malone and Rockart, 1991). Others found just the opposite effect; employment levels in Swedish insurance companies, for example, actually rose with the introduction of IT, a consequence attributed to the fact that the "effects of technological change always will be mediated and regulated by organizations and by society" (Stymne, Lowstedt and Fleenor, 1986). And this may be the nub of the matter: information, with its peculiar characteristics, was hard enough to understand in itself, but in the context of organisational norms and culture was even more problematic. Organisations are information organisms, they exist because of their outstanding capacity to deal with information (Macdonald, 1995). Their managers use information in many ways, but value information more for reinforcing organisational structure and for control than for knowledge. Hence the eagerness with which MIS was adopted. It is into this extraordinary, even artificial, world that IT was introduced (Jonscher, 1994). In these circumstances, to expect IT merely to replace information workers and to have a straightforward impact on productivity was always somewhat naive (Arrow, 1974).

One matter generally neglected in the literature is the relationship between IT and information as a source of power in the organisation. It really would have been amazing if parts of the organisation had not tried to capture information, and thus the power it bestowed, through IT (e.g., Hoos, 1960). In the strange information world of the organisation, where forgetting — disposing of information — may be as important as remembering (Lundvall and Johnson, 1994), where the distinction between personal information and organisational information is hazy, where managers live in constant fear of information overload, the role of IT, and hence its contribution to productivity, is not always clear. At the very least, some sort of balance had to be struck between the information requirements of the organisation and the information potential of IT.

"... companies need to balance their use of IT, enabling them to consider and incorporate both the explicit and tacit dimension of knowledge. In order to meet this challenge, we argue in favour of developing an information and a knowledge strategy prior to developing an IT strategy." (Johannessen, Oliasen and Olsen, 1999, p. 18)

Just as very few governments have ever developed an information policy, so very few companies have ever developed anything like an information strategy. The consequence was that IT was acquired and installed and exploited impulsively, and often under the overall charge of the finance director, neatly codified numbers being the sort of information both the organisation and IT handle

best. Under these circumstances, integrating IT with just about everything else in the organisation was likely to pose problems which might be reflected in productivity. Investing in IT was all very well, but IT could hardly be expected to change anything much on its own. There had to be complementary investment.

"... the greatest benefits of computers appear to be realised when computer investment is coupled with other complementary investments; new strategies, new business processes and new organizations all appear to be important in realizing the maximum benefit of IT." (Brynjolfsson and Hitt, 1998)

"Computerization does not automatically increase productivity, but it is an essential component of a broader system of organizational changes which does." (Brynjolfsson and Hitt, 1998, p. 11)

The 1980s was a decade of management in the way the 1970s had not been, in the way the 1990s continued to be, and in the sense that the performance of organisations was seen to be very much a function of how well they were managed. There was no shortage of advice on how to manage: MBA courses proliferated, the management consultancy industry became gigantic, and a whole new language of management method was developed. While it is hard to doubt the necessity for organisational investment complementary to investment in IT, it is also hard to share the enthusiasm of those authors who saw management method as unlocking the value of IT. Drucker (1988), for example, predicted that firms rich in IT would progress to flatter organisation, an organisational change as fundamental as that of 1895-1905 when managers became distinct from owners, and that of 1915-25 with the beginning of the modern command and control organisation. Observations that IT, even with management method, was not as productive as expected were countered with arguments that the wrong method was chosen, or that one or two new management methods were hardly enough to make a difference; the whole lot was essential (Kling, 1995).

"... successful moves towards the factory of 'the future' are not a matter of small adjustments made independently at each of several margins, but rather have involved substantial and closely coordinated changes in a whole range of the firm's activities. Even though these changes are implemented over time, perhaps beginning with 'islands of automation', the full benefits are achieved only by an ultimately radical restructuring." (Milgrom and Roberts, 1990, p. 513)

In this area, Thorow (1990) supplied the aphorism: "to computerize the office, you have to reinvent the office." This meant investing in the office.

"In 1994 this amounted to only about a 50% difference in overall IT investment intensity, however, this gap is

growing by 10% a year. Over the next decade, these decentralized and empowered organizations may begin to pull away from their industrial age counterparts in performance as they are better able to exploit increasingly inexpensive information technology." (Brynjolfsson and Hitt, 1998, p. 9)

Unfortunately for this argument, at least some of the very methods which the paradox literature argued were essential to making IT productive, have not been universally successful in other contexts. Business process re-engineering (BPR) is a good example; benchmarking, materials requirement planning (MRP), total quality management (TQM) are probably others (Thackray, 1993).

It can be argued that it is an emphasis on communication which distinguishes recent rashes of enthusiasm for management method from those which have preceded them. In a very real sense, networking and empowerment and decentralisation are enabled by telecommunications (Malone, 1997). The real power of IT, it is said, lies not in stand-alone computers, but in whole networks of computers. Ironical then that computing equipment which fits more properly within the telecommunications category is not regarded as IT at all and so has no impact on IT productivity as it is often measured.

7. Concluding Thoughts

The literature on the productivity paradox is exceptional in several ways. It is exceptional in that nearly all of it emanates from the United States (Greenan, Guellec and Mairesse, 1993). It is possible that US preoccupation with declining competitiveness against Japan and even Europe during the 1980s is partly responsible. The US looked to technological leadership to provide this competitiveness and went to great lengths to guard its technology for this very reason (Macdonald, 1990); ironic indeed was the possibility that the technology itself was the cause of declining competitiveness.

The literature is also exceptional in that there is a decided core which is infrastructural to the rest, and especially to the many articles which appear in the business press. It is extraordinary how much of this core literature hails from Massachusetts, and particularly from MIT, Harvard and the Sloan School. Research on the productivity paradox has been a minor industry in Massachusetts for at least a decade. Had the expertise been more dissipated, there might have been more opportunity for taking different approaches to the research, and for voicing different opinions. It may be that the dominance of Massachusetts has discouraged European research on the productivity paradox, but other factors are much more likely to account for the virtual absence of research on the topic in the UK, for example. Chief among these is probably that there has been little research money for academics to

study the paradox. Academic research in the UK must be user-driven and enthusiastic if it is to stand any chance at all of being funded. Unfunded research is simply unperformed. One consequence is much uncritical emphasis on success stories, especially the strategic ones, and relegation of IT failures, of which there are many and some quite catastrophic, to a highly specialised technical literature quite unconcerned with productivity (Kumar, 1990).

The primary literature of the productivity paradox is in economics and management, and the secondary literature is in the business press. The economists and the econometricians have used the issue as a platform on which they can regress their equations into eternity, and management researchers have used it to prescribe an infinity of ways for managers to cope with the paradox. It has not really been in the interests of either group to resolve the issue. The primary literature has two concerns: whether there really is a productivity paradox; and, given that there is, what to do about it. Economics, and especially econometrics, has looked after the first concern: management after the second. There has often been little link between the two, which may be a reflection of their relative status in the academic world. In as much as the two have made common cause, it has been to argue that productivity from IT is important because competitiveness is dependent upon it. But there would seem to be no place in the discussion for the notion that competitiveness can also be dependent on innovation. This is odd because IT is itself an innovation — perhaps the most significant innovation for decades — and there is a vast literature on the link between innovation and competitiveness. Why has this literature not concerned itself with the productivity paradox? Part of the reason may be that Massachusetts established the standard in permitted approaches to the subject, and neither economics nor management is especially strong on technology. This is a pity; the innovation literature would have cast the productivity paradox in a different light. For example, it would have been accepted that there would be problems in adopting IT just as there are in adopting any other innovation, and that these problems are not likely to be solved by the simple application of management method. It would certainly have suggested long ago the importance of the analogy with R&D. Rather than whipping the dead horse of the paradox issue, it may be better to change course and look at IT as part of the infrastructure required for innovation and competitiveness. Thus, IT would indeed be analogous to R&D, from which it is generally accepted that there can be no specific calculations of output (Macdonald, 1986).

"This finding leads to more general observations about the way executives make decisions about IT. Just as they do with R&D, they depend heavily on intuitive and nonfinancial measures as well as formal financial justification ... The analogy with other forms of R&D is striking. Most other technical breakthroughs also take years or decades

to achieve paybacks, with company and industry indicators in the meantime showing low (or negative) paybacks. As with IT, few companies routinely try to evaluate the aggregate impact of all their R&D projects. Instead, they appraise effects on a project-by-project basis in terms of how well each project supports other strategic goals. For both R&D projects and IT programs, payoffs are likely to be uncertain in both scale and timing." (Quinn and Baily, 1994, p. 41. See also National Research Council, 1994)

The difference in approach to IT and R&D is evident in attitude towards failure. Managers are always reluctant to admit to any sort of failure. Failure in IT tends to be seen as an indictment of management, while mistakes in R&D are often seen as respectable, even inevitable.

There is a trade-off between efficiency and flexibility in the organisation. The emphasis has long been on using IT for efficiency in order to achieve competitiveness. It may be time to redirect this emphasis to flexibility, to gaining competitiveness through the ability to change, to innovate (Monteiro and Macdonald, 1996).

"The [learning economy] concept refers first of all to the ICT (information and communication technologies)-related techno-economic paradigm of the post-Fordist period. It is through the combination of widespread ICT technologies, flexible specialisation and innovation as a crucial means of competition in the new techno-economic paradigm, that the learning economy gets firmly established. Firms start to learn how to learn." (Lundvall and Johnson, 1994, p. 26)

It is because firms do not know how to learn, how to handle information for innovation, that they use IT largely for efficiency (Macdonald, 1995). Basically they use IT in an attempt to do better what they are already doing.

The IT industry is vast and powerful, and governments are anxious to promote its products, justifying their policies and programmes in terms of the competitiveness IT brings. If the productivity paradox discussion shows anything at all, it must be that the issue is extraordinarily complicated. This sits ill with the stance taken by the IT industry and by governments, which is basically to encourage as much use of IT as possible. Is it possible to adapt a fundamentally mono-dimensional approach to incorporate some of the lessons learnt from research into the productivity paradox?

"If the spending on computers is correlated with significantly higher returns than spending on other types of capital, it does not necessarily follow that companies should increase spending on computers. The firms with high returns and high levels of computer investment may differ systematically from the low performers in ways that can not be rectified simply by increasing spending." (Brynjolfsson and Hitt, 1993. See also Brynjolfsson and Hitt, 1996, p. 556)

The suggestion is strong that some organisations, for whatever reason, benefit much more than others from IT. Consequently, policy which encourages all organisations to adopt IT, whatever their circumstances, is unlikely to be helpful. It follows that effort is required to discover just which organisations will benefit from IT, and from government incentive programmes encouraging the adoption of IT.

The productivity paradox discussion has also made clear that productivity cannot be expected from IT alone; the IT must be accompanied by appropriate management. The customary stance has been that IT is primary and management is a secondary matter, an enabling technology in innovation terms. But it is just as valid to reverse this traditional argument so that productivity is considered to come not primarily from the IT, but from management methods underpinned by IT.

"This is further supported by our finding that the rate of return for computer capital is highest for high performing firms — these are presumably the firms that have engaged in the most innovative improvements." (Brynjolfsson and Hitt, 1993)

The discussion has indicated that there is little to be gained in looking at the conventional productivity measures even more closely to find the impact of IT. So much of whatever it is that IT does does not improve conventional productivity. Consequently, to concentrate on ever more refined productivity measurement techniques is to miss the point.

The discussion also suggests that new management methods are not simply facilitated by IT, but may actually be dictated by IT. The fashion of the 'seventies was to perceive technology as deterministic, a fashion which did not survive growing appreciation that how the technology was used was at least as important as the technology itself. In IT, this was reflected in the growing suspicion that managers rather than IT itself were responsible for the productivity paradox. Obviously this allocation of blame suited the IT manufacturers and suppliers, but it also suited the management consultants, a group which had been evident in the identification of the productivity paradox on 1987, and which had fuelled the treatment of the subject in the business press. The management consultancy industry had become huge by the late 'eighties, and its continued growth depended on what is known as the 'churn', the supplementing of existing management methods with new ones (Abrahamson, 1996; Huczynski, 1993). Concern about the organisational change required to make IT investment productive was a godsend for management consultants, who both satisfied and fuelled the concern with management method (Sturdy, 1997). Indeed, much management consultancy, especially in the larger firms, had sprung from IT consultancy, a reality which is perhaps reflected in many of the methods of management consult-

ing being possible only through the exploitation of IT. From prosaic just-in-time methods through notions of networking organisations to the idea of the virtual organisation, the contribution of IT to management consulting is evident.

There is a more subtle link between the organisational change required for IT and management method. It is curious how so many of the most fashionable methods are not only appropriate to IT, but are actually determined by it. For instance, a whole raft of methods intended to make organisations more customer-oriented can be explained in terms of the inability of these organisations to capture the benefits from their IT investments. Or again, the wholesale change demanded by business process re-engineering encompassed and excused absolutely any organisational change required for IT. Similarly, it is quite possible to see the slim organisation and contracting out as methods for capping runaway IT expenditure.

The contribution of the business press to general understanding of the productivity paradox has generally been neither intelligent nor helpful. The business press has usually been sensationalist, much more interested in finding a direct relationship between the paradox issue and the latest management fad than in exploring the complexities and subtleties of either. Indeed, what was a discussion propagated by the business press came to be justified in terms of the attention it was given by the business press.

“... why were there so many articles in *Fortune* and *Business Week* over the past decade about the difficulties encountered by many firms in structuring their organizations and work processes to use computers effectively?” (Gordon, 1994, p. 326)

The resolution of the productivity paradox depended as much on the requirements of the business press as on the efforts of academics. Too much bad news was bad for business.

“Perhaps because it is unexpected and thus more newsworthy, the bad news in the research reports has received more press. The impression one gets from the trade and management literature is one of solid consensus that firms’ IT expenditures have been badly placed bets.” (Markus and Soh, 1993, pp. 375–403)

Bad news could not be allowed to become a permanent feature of IT stories, and not simply because it became predictable and tedious. Given that so much high technology stock was — and still is — overvalued, a serious fall in confidence in IT could not be countenanced (Ralston, 1998). Brynjolfsson and Hitt calculated that the stock market valued \$1 of investment in IT at \$10, which they ex-

plained in terms of there being \$9 of intangible investment for each \$1 invested in IT. When they announced that the paradox had been resolved, *Business Week* had no hesitation in declaring that prodigious IT investment had been a great idea after all.

“... the productivity surge of the last two years ... may reflect the efforts of US companies to finally take full advantage of the huge sums they’ve spent purchasing information technology” (Mandel, 1994, pp. 273–4)

In Australia, *Business Review Weekly* heaved a more belated sigh of relief and attributed the responsibility to even better management methods and even greater investment in IT (Banaghan, 1996)

Agreement that the productivity paradox is past is not unanimous. A very recent paper still finds that productivity declines with investment in IT — and in both the service and manufacturing sectors (Dasgupta, Sarkis and Talluri, 1999). The paper attributes the paradox to a new cause — the cost of co-ordination. Given that so much IT is exploited to reduce this very cost, there would seem to be as much paradox as ever.

“... as firms invest more in information technology there is a greater need for co-ordination between different activities and systems across all functional areas of the organization. This could be a possible reason for the negative impact of information technology investment on firm performance.” (Dasgupta, Sarkis and Talluri, 1999, p. 128)

Actually there may be benefits in the failure to resolve the productivity paradox. The very Roach who was so prominent in initiating the discussion now reckons there is value in the paradox remaining unresolved. The productivity paradox has value as an enduring reminder that the relationship between IT and the organisation is inherently complex and subtle. Those concerned with measuring or with managing IT have perhaps neglected these characteristics.

“Let memories of the paradox endure ... as a warning of how easy it is to stray from the path.” (Roach, 1994, p. 55)

Acknowledgement

This paper is based on a report — *Government Policy and the Productivity Paradox. Economic Study to Support the ISI Evaluation* — the authors produced in November 1999 for the Department of Trade and Industry in London. The authors are very grateful to DTI officials, and especially to Anne Brown, for their assistance in producing the report and for their permission to publish this version.

References

- Abrahamson, E. (1996): Management Fashion. In: *Academy of Management Review*, Vol. 21, 254–285.
- Agrawal, R., S. Findley et al., (1996): Capital Productivity: Why the US Leads and Why it Matters. In: *McKinsey Quarterly*, Vol. 3, 38–55.
- Arrow, K. (1974): *The Limits of Organization*, New York.
- Attewell, P. (1993): Why Productivity Remains a Key Measure of IT Impact, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC., 4–5.
- Baily, M., A. Chakrabarti (1988): Electronics and White-Collar Productivity. In: *Innovation and the Productivity Crisis*, Washington DC.
- Baily, M., R. Gordon (1988): The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power. In: *Brookings Papers on Economic Activity*, Vol. 1, 347–420.
- Bakos, Y., P. de Jager (1995): Are Computers Boosting Productivity? In: *Computerworld*, Vol. 27, 128–130.
- Banaghan, M. (1996): The Productivity Paradox. In: *Business Review Weekly*, May 13, 70–73.
- Barua, A., B. Lee (1997). The Information Technology Productivity Paradox Revisited: A Theoretical and Empirical Investigation in the Manufacturing Sector. In: *International Journal of Flexible Management Systems*, Vol. 9, No. 2, 145–166.
- Brynjolfsson, E. (1993): The Productivity Paradox of Information Technology. In: *Communications of the ACM*, Vol. 36, No.1, 67–77.
- Brynjolfsson, E., L. Hitt (1993): New Evidence on the Returns to Information Systems, Technical Report, Sloan School of Management, Cambridge MA.
- Brynjolfsson, E., L. Hitt (1996): Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending. In: *Management Science*, Vol. 42, No. 4, 541–558.
- Brynjolfsson, E., L. Hitt (1997): Computing Productivity: Are Computers Pulling their Weight?, MIT and Wharton Working Paper (available at <http://ccs.mit.edu/erik/>).
- Brynjolfsson, E., L. Hitt (1998): Beyond the Productivity Paradox: Computers are the Catalyst for Bigger Changes. In: *Communications of the ACM*, Vol. 41, No. 8, 49–55.
- Brynjolfsson, E., T. Malone, V. Gurbaxani, A. Kambil (1994): Does Information Technology Lead to Smaller Firms? In: *Management Science*, Vol. 40, No. 12, 1628–1644.
- Brynjolfsson, E., A. Renshaw, M. van Alstyne (1997): The Matrix of Change. In: *Sloan Management Review*, Vol. 38, No. 2, 37–54.
- Cash, J., B. Konsynsk (1985). IS Redraws Competitive Boundaries. In: *Harvard Business Review*, Vol. 63, 134–142.
- Currie, W. (1989): The Art of Justifying New Technology to Top Management. In: *Omega*, Vol. 17, No. 5, 409–418.
- Dasgupta, S., J. Sarkis, S. Talluri (1999): Influence of Information Technology Investment on Firm Productivity: A Cross-Sectional Study. In: *Logistics Information Management*, Vol. 1/2, No. 12, 120–129.
- David, P. (1990): The Dynamo and the Computer: A Historical Perspective on the Modern Productivity Paradox. In: *American Economic Review Papers and Proceedings*, Vol. 1, No. 2, 355–361.
- Davis, G., R. Collins, M. Eierman, W. Nance (1993): Productivity from Information Technology Investment in Knowledge Work. In: R. Barker, R. Kauffman, M. Mahmood (eds.), *Strategic Information Technology Management*, Harrisburg PA, 327–343.
- Davis, T. (1991): Information Technology and White-Collar Productivity. In: *Academy of Management Executive*, Vol. 5, No.1, 55–67.
- de Long, J., L. Summers (1991): Equipment Investment and Economic Growth. In: *Quarterly Journal of Economics*, Vol. 106, No. 2, 445–502.
- Dewan, S., S. Min (1997): The Substitution of Information Technology for Other Factors of Production: A Firm Level Analysis. In: *Management Science*, Vol. 43, No. 12, 1660–1675.
- Diewert, W., E. Fox (1997): Can Measurement Error Explain the Productivity Paradox?, University of New South Wales, School of Economics Discussion Paper No. 27.
- Docherty, P., B. Stymne (1993): Mediators of IT-Effectiveness, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.
- Drucker, P. (1988): The Coming of the New Organization. In: *Harvard Business Review*, Vol. 66, No.1, 45–53.
- Economist* (1994): What Computers Are For?, 22 January, 68.
- Economist* (2000): Performing Miracles, 17 June, 118.
- Ellis, L., C. Curtis (1995): Measuring Customer Satisfaction. In: *Research Technology Management*, Vol. 38, No. 5, 45–48.
- Farbey, B., F. Land, D. Targett (1992): Evaluating Investments. In: *IT, Journal of Information Technology*, Vol. 7, 109–122.
- Feigenbaum, A. (1985): *Total Quality Control*, New York.
- Freeman, C., L. Soete (1994): *Work for All or Mass Unemployment?*, London.

- Freeman, K., J. Dart (1993): Measuring the Perceived Quality of Professional Business Services. In: Journal of Professional Services Marketing, Vol. 9, No. 1, 227–247.
- Garvin, D. (1987): Managing Quality, New York.
- Gordon, R. (1987): The Postwar Evolution of Computer Prices, National Bureau of Economic Research Working Paper 2227.
- Gordon, R. (1994): Comment on S.D. Oliner and D.E. Sichel, Computers and Output Growth Revisited: How Big Is the Puzzle? In: Brookings Papers on Economic Activity Vol. 2, 273–333.
- Greenan, N., D. Guellec, J. Mairesse, (1993): Computers and Productivity in France: Data Sources and Some Preliminary Evidence, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.
- Henderson, R. (1994): Managing Innovation in the Information Age. In: Harvard Business Review, Vol. 1, 100–105.
- Hoose, I. (1960): When the Computer Takes Over the Office, In: Harvard Business Review, Vol. 38, No. 4, 102–112.
- Huczynski, A. (1993): Explaining the Succession of Management Fads. In: International Journal of Human Resource Management, Vol. 4, No. 2, 443–463.
- Hurley, F., M. Laitamaki (1995): Total Quality Research: Integrating Markets and the Organization. In: California Management Review, Vol. 38, No. 1.
- Johannessen, J.-A., J. Olaisen, B. Olsen (1999): Strategic Use of Information Technology for Increased Innovation and Performance. In: Information Management and Computer Security, Vol. 7, No. 1, 5–22.
- Jonscher, C. (1994): An Economic Study of the Information Technology Revolution. In: T. Allen, M. Scott Morton (eds.), Information Technology and the Corporation of the 1990s, New York, 5–42.
- Jorgenson, D., K. Stiroh (1993): Investment in Computers and U.S. Economic Growth, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.
- Jorgenson, D., K. Stiroh (1999): Information Technology and Growth. In: American Economic Review, Vol. 89, No. 2, 109–115.
- Kaplan, R. (1989): Management Accounting for Advanced Technological Environments. In: Science, Vol. 25, 819–823.
- Kling, J. (1995): High Performance Work Systems and Firm Performance. In: Monthly Labour Review, Vol. 118, No. 5, 29–36.
- Kordupleski, R., R. Rust, A. Zahorik (1993): Why Improving Quality Doesn't Improve Quality (or Whatever Happened to Marketing?): In: California Management Review, Vol. 35, No. 3, 82–95.
- Kumar, K. (1990): Post-Implementation Evaluation of Computer-Based Information Systems: Current Practices. In: Communications of the ACM, Vol. 33, No. 2, 203–212.
- Landauer, T. (1996): The Trouble with Computers: Usefulness, Usability and Productivity, Cambridge MA.
- Lichtenberg, F. (1993): The Output Contributions of Computer Equipment and Personnel: A Firm-Level Analysis, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.
- Lumkin, G., G. Dess (1996): Clarifying the Entrepreneurial Orientation Construct and Linking it to Performance. In: Academy of Management Review, Vol. 21, No. 1, 135–172.
- Lundvall, B.-A., B. Johnson (1994): The Learning Economy. In: Journal of Industry Studies, Vol. 1, No. 2, 23–42.
- Macdonald, S. (1986): Theoretically Sound: Practically Useless? Government Grants for Industrial R&D in Australia. In: Research Policy, Vol. 15, 269–283.
- Macdonald, S. (1990): Strategic Export Controls. Hurting the East or Weakening the West?, London.
- Macdonald, S. (1995): Learning to Change: An Information Perspective on Learning in the Organization. In: Organization Science, Vol. 6, No. 5, 557–568.
- Malone, T., J. Rockart (1991): Computers, Networks and the Corporation. In: Scientific American, Vol. 265, No. 3, 128–136.
- Malone, T. (1997): Is Empowerment Just a Fad? Control, Decision Making and IT. In: Sloan Management Review, Vol. 38, No. 2, 23–35.
- Mandel, M. (1994): The Digital Juggernaut. In: Business Week, special bonus issue, 22–31.
- Mandeville, T., S. Macdonald (1980): Reflections on the Technological Change Debate. In: Australian Quarterly, Vol. 52, No. 2, 213–220.
- Markus, M., C. Soh (1993): Banking on Information Technology: Converting IT Spending into Firm Performance. In: R. Barker, R. Kauffman, M. Mahmood (eds.), Strategic Information Technology Management, Harrisburg PA, 375–403.
- McKeen, J., H. Smith (1993): The Relationship between Information Technology Use and Organizational Performance. In: R. Barker, R. Kauffman, M. Mahmood (eds.), Strategic Information Technology Management, Harrisburg PA, 405–44.
- Milgrom, P., J. Roberts (1990): The Economics of Modern Manufacturing: Technology, Strategy and Organization.

- tion. In: *American Economic Review*, Vol. 80, No. 3, 511–528.
- Monteiro, L., S. Macdonald (1996): From Efficiency to Flexibility: The Strategic Use of Information in the Airline Industry. In: *Strategic Information Systems*, Vol. 5, No. 3, 169–88.
- National Research Council (1994): *Information Technology in the Service Society: A Twenty-First Century Lever*, Washington DC.
- Oliner, S., D. Sichel (1994): Computers and Output Growth Revisited: How Big is the Puzzle? In: *Brookings Papers on Economic Activity*, Vol. 2, 273–333.
- Pinsonneault, A., S. Rivard (1998): Information Technology and the Nature of Managerial Work: From the Productivity Paradox to the Icarus Paradox. In: *Management Information Systems*, Vol. 22, No. 3, 287–308.
- Popkin, J. (1993): Measurement Problems in Quantifying Information Technology's Contribution to Productivity, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.
- Porat, M. (1977): *The Information Economy: Definition and Measurement*, Washington DC.
- Porter, M., V. Millar (1985): How Information Gives You Competitive Advantage. In: *Harvard Business Review*, Vol. 63, 149–160.
- Quinn, J.B., M.N. Baily (1994): Information Technology: The Key to Service Performance. In: *Brookings Review*, Summer, 36–41.
- Quinn, J.B., M.N. Baily (1994): Information Technology: Increasing Productivity in Services. In: *Academy of Management Executive*, Vol. 8, No. 3, 28–47.
- Quinn, J.B., J. Humble (1993): Using Service to Gain a Competitive Edge. The PROMPT Approach. In: *Long Range Planning*, Vol. 26, No. 2, 31–40.
- Ralston, G. (1998): No Productivity Paradox, *Educom Review*, May/June, 36–38.
- Reichheld, F. (1993): Loyalty-Based Management. In: *Harvard Business Review*, Vol. 71, No. 2, 64–73.
- Roach, S. (1994): Lessons of the Productivity Paradox. In: *Computerworld Premier 100*, Vol. 19, 55.
- Romer, D. (1988): Comment. In: *Brookings Papers on Economic Activity*, Vol. 2, 425–428.
- Schrednick, H., R. Schutt, M. Weiss (1992): Empowerment — Key to World-Class Quality. In: *MIS Quarterly*, Vol. 16, No. 4, 491–505.
- Solow, R. (1987): We'd Better Watch Out, review of S.S. Cohen and J. Zysman, *Manufacturing Matters: The Myth of the Post-Industrial Economy*, New York Times Book Review, 36.
- Son, Y. (1990): A Performance Measurement Method which Remedies the Productivity Paradox. In: *Production and Inventory Management Journal*, Vol. 2, No. 31, 38–43.
- Stoneman, P., N. Francis (1994): Double Deflation and the Measurement of Output and Productivity in UK Manufacturing 1979–89. In: *International Journal of the Economics of Business*, Vol. 1, No. 3, 423–437.
- Stoneman, P., D. Bosworth, D. Leech, D. McCausland (1992): *Quality Adjusting the Producer Price Index for Computers in the UK*, report to the Central Statistical Office, London.
- Strassman, P. (1985): *Information Payoff: The Transformation of Work in the Electronic Age*, New York.
- Strassman, P. (1994): How We Evaluated Productivity. In: *Computerworld Premier 100*, Vol. 19, 45.
- Strassman, P. (1997): *The Squandered Computer: Evaluating the Business Alignment of Information Technologies*, New Canaan CT.
- Sturdy, A. (1997): The Consultancy Process — An Insecure Business? In: *Journal of Management Studies*, Vol. 34, No. 3, 389–413.
- Stymne, B., J. Lowstedt, C. Fleenor (1986): A Model for Relating Technology, Organization and Employment Level. A Study of the Impact of Computerization in the Swedish Insurance Industry. In: *New Technology, Work and Employment*, Vol. 1, No. 2, 113–126.
- Teas, R. (1993): Expectations, Performance Evaluation, and Consumers. In: *Journal of Marketing*, Vol. 57, No. 4, 18–34.
- Thackray, J. (1993): Fads, Fixes and Fictions, *Management Today*, June, 40–42.
- Thurow, L. (1987): Economic Paradigms and Slow American Productivity Growth. In: *Eastern Economic Journal*, Vol. 13, 333–343.
- Thurow, L. (1990): *Are Investments in Information Systems Paying Off?*, MIT Management, Spring.
- Triplett, J., R. Gordon (1994): Comments on Oliner, S.D. & Sichel, D.E. Computers and Output Growth Revisited: How Big is the Puzzle? In: *Brookings Papers on Economic Activity*, Vol. 2, 273–333.
- Weill, P. (1993): The Role and Value of Information Technology Infrastructure: Some Empirical Observations. In: R. Barker, R. Kauffman, M. Mahmood (eds.), *Strategic Information Technology Management*, Harrisburg PA, 547–572.
- Willcocks, L., S. Lester (1996): Beyond the IT Productivity Paradox. In: *European Management Journal*, Vol. 14, No. 3, 279–290.
- Wilson, D. (1993): Assessing the Impact of Information Technology on Organizational Performance. In: R.

- Barker, R. Kauffman, M. Mahmood (eds.), Strategic Information Technology Management, Harrisburg PA, 471–514.
- Windschuttle, K. (1979): Unemployment, Ringwood, Victoria.
- Wiseman, I. Macmillan (1984–5): Creating Competitive Weapons from Information Systems. In: Journal of Business Strategy, Vol. 5, 42–49.
- Wyckoff, A. (1993): The Impact of Computer Prices on International Comparisons of Productivity, paper presented to the Productivity Impacts of Information Technology Investments Conference, Charleston SC.

Zusammenfassung

Messproblem oder Managementproblem — Eine Revision des Produktivitätsparadoxons der Informationstechnologie

1999 gab das Department of Trade and Industry in London einen umfassenden Literaturüberblick über das Produktivitätsparadox in der Informationstechnologie in Auftrag. Der vorliegende Beitrag beruht auf diesem Projekt. Die Autoren stellten fest, dass die Diskussion des Produktivitätsparadoxons größtenteils in den Vereinigten Staaten und teilweise in Massachusetts stattfand. Zwei sehr unterschiedliche Betrachtungsansätze bestimmen die Produktivitätsparadox-Diskussion: Die volkswirtschaftliche Literatur forscht nach immer besseren Messmethoden, und die betriebswirtschaftliche Literatur beschäftigt sich mit der Suche nach immer besseren Managementmethoden. Der vorliegende Beitrag konzentriert sich hauptsächlich auf die zweite Betrachtungsweise. Als Schlussfolgerung ergibt sich, dass der Zusammenhang zwischen Managementmethoden und Anforderungen der Informationstechnik weitaus enger ist als bisher angenommen wurde. Für die enttäuschenden Produktivitätswirkungen der Informationstechnik ist nicht ein einzelner Faktor, sondern wahrscheinlich eine Kombination von Faktoren verantwortlich. In dieser Kombination sind die Probleme, die sich Managern in der Nutzung von IT stellen, und die Betätigungsmöglichkeiten für Unternehmensberater besonders interessant.