International Journal of Information Management (1989), *9* (275–288)

Information Needs for the Information Economy

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There is a marked imbalance in the literature on the information economy: despite a proliferation of grand speculations, and a large number of case studies, there are relatively few efforts to bring macrostatistics to bear on relevant developments. The main approach which has been pursued statistically, involving efforts to define and monitor an 'information sector' has served a useful consciousness-raising role, but is inherently limited. It is proposed that a focus on the production and use of new information technology (IT) provides a more appropriate way of conceptualizing the information economy. A study is described in which relevant data were critically appraised for the United Kingdom; the conclusions with respect to specific classes of data are summarized. It is concluded that these data do support an IT focus in statistical work; they demonstrate the availability of a great deal of statistical material which has been exploited to a surprisingly limited extent; but there are substantial elisions and omissions in available data, which need to be corrected. Rather than launch a wholesale revision of statistical series, however, it is proposed that progress can currently best be made by encouraging a plurality of experimental studies.

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The research on which this paper is based was generously supported by the Programme on Information and Communication Technologies of the Economic and Social Research Council. It draws on studies carried out with a number of colleagues at SPRU and elsewhere, to whom gratitude should be expressed: Tim Brady, Andy Davies, Leslie Haddon, Nick Jagger, Robin Mansell, Mark Matthews, Mary Newsom, Howard Rush, Sally Wyatt, in particular. The paper was prepared while the author was a Visiting Professor at the Department of Technology and Social Change, University of Linköping, Sweden: I would like to thank my hosts there for their hospitality and stimulation.

Introduction

There are several paradoxes associated with new information technology (IT). For example, IT is widely seen as meaning the displacement of traditional paper texts by new electronic media. But many shelves of books have been devoted to discussing its applications and its social and economic consequences! Furthermore, despite these mounds of verbiage, and despite a good many valuable case studies and efforts at generalization from these, rather little is systematically known about the patterns of diffusion and application of IT.

The lack of systematic knowledge has not deterred — indeed, it may have stoked the need for — production of so many commentaries, accounts of localized experiences, and speculative efforts to divine current and future patterns of development. A more interesting point follows from the continued dominance of traditional print media as means of scientific discourse. For this demonstrates that the process of technological substitution is by no means as automatic as proponents of new technologies sometimes imagine. Indeed, there may be good reasons to stick with the traditional technologies, at least until the parameters of the new innovations seem to have settled down. Early innovators sometimes gain substantial advantages — but they often find themselves bogged down in problems of standards, poor support systems, lack of skills, and the like.

This point applies also to innovations in statistics about IT. While the shortcomings of available data are widely deplored, the lack of information on IT itself reflects in part the understandable resistance of statistical agencies and established researchers to drop their existing tools and problem areas to swarm into research on IT. Those of us who are interested in developing new data on IT should be well aware of the advantages conferred by the relatively slow pace of change in statistical

0268–4012/89/04 0275–14 $03.00

systems: the work saved and precision gained by being able to construct reasonable time-series without having to compensate for changes in statistical definitions are considerable.

Yet there are many reasons for wishing that better data on IT development were available. For instance, the 'Warren Committee' report on information technology — a report of the House of Commons' Trade and Industry Committee, a prestigious group of Members of the British Parliament — made many points about needs for improved statistics, arguing that it is difficult to formulate and evaluate policies without appropriate statistics:

> Better information might help to provide a greater understanding of the deep inherent challenge to the UK manufacturing base . . . the DTI should collect and publish figures for the balance of trade of the larger electronics companies, showing the proportion of goods and services purchased from UK and EEC sources compared with sales in those markets . . . Any attempt to measure the state of the market, the industry or the balance of trade is hindered by the inadequacy of statistics . . . We also recommend that the Government should, in collaboration with the European Community and the Organisation for Economic Cooperation and Development, seek a new standard industrial classification covering information technology goods and services.[1]

The purpose of this article is to explore what data actually are available to assess IT activities in the UK, to identify the scope for making improved use of these data, and to consider the prospects for improved statistical information.

The problem with the information economy

It is important to be clear about our objectives. It may, then, be helpful to contrast the present approach with one that has achieved considerable institutional support as a way of measuring what is variously termed the information age, information economy, or information society. (It is, for example, one of the main approaches used by contributors to Williams' *Measuring the Information Society*.[2]) This is an approach based not on assessing change associated with information technology, but on information activities.

Beginning with Machlup's pioneering work, and continuing with several modifications in the studies of Porat, considerable effort has been devoted to establishing the scale of information work in economies. The OECD, for example, has produced a number of studies in which the growth of information work as a share of all employment is charted. Similar studies have proliferated for many industrial and developing countries, and they certainly play a useful role in highlighting the importance of this sort of work.[3]

But this is not the same as describing or accounting for the role of information in our economies: we shall only summarize two of the limitations of this approach here. First, these data are telling us only about those types of information work that have become specialized activities. Often this has involved abstracting certain types of information-processing from manual or other jobs, in the advancing division of labour. But all jobs, of course, require the worker to engage in some information-processing, however deskilled the job may be. This is one reason why the application of IT to industry (e.g., robots) can

[1] TRADE AND INDUSTRY COMMITTEE (1988). *Information technology*, Vol. 1, pp. xiii–xiv. London: Her Majesty's Stationery Office.

[2] WILLIAMS, F. (1988). *Measuring the information society*. Newbury Park, California: Sage Publications.

[3] MACHLUP, F. (1962). *The production and distribution of knowledge in the United States*. Princeton, NJ: Princeton University Press. This is the classic study; for a subsequent study in this tradition see RUBIN, M.R. AND HUBER, M.T. (1986). *The knowledge industry in the United States 1960–1980*. Princeton, NJ: Princeton University Press. The recent resurgence of such work is largely based on ideas established in PORAT, M. (1976). *The information economy*. Washington, DC: US Department of Commerce, Office of Technology. For further studies in this tradition see: KATZ, R.L. (1986). Measurement and cross-national comparisons of the information work force. *The Information Society, 4* (No. 4), pp. 231–277. OECD (1981). *Information activities, electronics and telecommunications technologies*, Vol. 1. Paris: OECD (ICCP series). OECD (1986). *Trends in the information economy*. Paris: OECD (ICCP series). WILLIAMS, *op cit.*, Ref. 2.

affect so-called production workers as well as the information workforce! In this sense, all economies are and have always been information economies, since information-processing is an integral part of their functioning; all that makes advanced industrial economies different is the secular growth of specialized information work. In contrast, an IT focus does draw attention to a new development within industrial societies, for the new technologies represent more than a further step in the slow evolution of information activities and in the slow process of application of technologies of all types to information processing.

A second problem with the 'information activity' approach is that 'information' itself is treated in a rather mysterious way, and is not itself subject to further analysis. Admittedly, in the work of Porat and his followers, distinctions are drawn between different types of information work. One distinction is between work in the *primary information sector* (producing information products as its output) and the *secondary information sector* (producing information inputs to production of supposedly non-information goods and services, although it is arguable that all products involve some informational components!). Another distinction is between information *producers, processors, distributors*, and *infrastructure workers*. This tells us a little about how different occupations are servicing information, but little about what it is being applied to. Furthermore, the categories of work subsumed under the different headings are often extremely heterogeneous: information producers, for example, range from chemists, optometrists and civil engineers to stockbrokers, composers and programmers. (Journalists, meanwhile, are information distributors, and photographers are regarded as infrastructure workers.) Not all the categories of information worker grow over time, but enough do for the impression to be created that there is some sort of mysterious social demand for increasing amounts of information driving the system along — but what this is remains unspecified.[4]

It has been useful for the importance of information in economic affairs to be highlighted in this way, but this approach does not seem to throw much light on the dynamics of the information economy. Is it plausible that the growth paths of so many highly varied classes of information work share a common explanation? How can these trends be interpreted as cumulating in a new phase in socioeconomic development? What changes are taking place in the role and processing of information? The many statistical studies following the Porat approach fail to illuminate these topics more than dimly. Perhaps the lure of a single indicator (the size of the 'information sector' or the proportion of total employment taken by the 'information workforce') has had the same enervating effect on information economy research as the search for a philosopher's stone-like Quality of Life Index did for the social indicators movement.[5] Or perhaps the enthusiasm for this approach stems from the fact that it basically involves a reclassification of familiar occupational statistics, and does not require economists or sociologists to explore unfamiliar new categories of data. Nor does it challenge them to get to grips with technology, a subject which the social sciences have been notably reluctant to tackle.[6]

An information technology focus

Our focus on IT rather than on 'information activities' stems in part

[4]See MILES AND GERSHUNY for a discussion of this point, which is among the similarities between the 'information activity' approach and earlier accounts of 'post-industrial society': MILES, I. AND GERSHUNY, J. (1986). The social economics of information technology. In: *New communications technology and the public interest* (M. FERGUSON, ed). London: Sage.

[5]See MILES for a discussion of the social indicators movement; it should be noted that the Machlup approach did not seek to generate a single indicator — which may have accounted for its being overshadowed by Porat's work: MILES, I. (1985). *Social indicators for human development*. London: Frances Pinter.

[6]With some notable exceptions, notably the recent study by Hill: HILL, S. (1988). *The tragedy of technology*. London: Pluto.

from the critique of the Porat approach sketched in above. New IT is associated with changes in the production and use of information. Assessing the social and economic role of current (and traditional) information technologies in this light may be one of the most productive ways of studying the nature of information activities. And, as noted at the outset, the economic importance of IT makes this an important area to study. But there is another rationale for this interest: one which simultaneously makes the task of empirically focusing on IT both more urgent and more challenging. This casts a new light, too, on whether the 'information economy' is a distinct phase of economic development.

Recent research — especially that in the so-called neoSchumpeterian school of economics[7] — has demonstrated the value of conceptualizing the development of industrial economies in terms of a succession of technological revolutions. In contrast to the standard economists' focus on structural regularities, this draws attention to structural change. A technological revolution involves change across a wide span of economic activities and sector, associated with the diffusion of new techniques based on a new set of core technologies (steam engines, electricity, electronics, etc.). Core technologies involve the processing of energy, materials, or information; and a revolutionary technology is one that offers a dramatic improvement on an earlier core technology, in such a fashion that it can be economically applied in many products and production processes. The development of a revolutionary technology, providing it is socially acceptable, leads to the rise to prominence of new core sectors, to new diffusion patterns and flows between industrial sectors, and to the emergence of new industries and firms based on the applications of the core technologies. New IT, based on the cheapening of programmable information-processing power enabled through microelectronics, represents such a revolutionary core technology.[8]

The analysis of technological revolutions goes on to point out that the culmination of these developments around a new core technology is a transformation of the economy — a new system of relationships has been called into being, with some elements of the old preserved, of course, but with many new features developed around these. Authors variously refer to this as a new regime, a new technoeconomic paradigm, a new technological system, or a new sociotechnical system.[9] Here, then, is an approach that does provide a rationale for considering that industrial economies are entering a new phase, although authors may differ as to the timing of this, or as to the relative causal weight to be given to technological, economic, political and other factors.

Terms like 'information economy', 'information age' and the like may be rather misleading in that by omitting 'technology' they skirt the specificity of the new sociotechnical system; but phrases such as 'the informatization of society' are too much of a mouthful to ever be accepted, while 'telematic society' and 'computerized society' are too specific. Whatever labels are used, the real challenge is to develop and deploy data relevant to describing and modelling an industrial society in which a technological revolution is taking place, so that new IT is being widely applied. In some ways this is a more industrial society, a super-industrial or meta-industrial society, rather than a post-industrial one. For new IT is resulting in the application of technology within services on a large scale — and services have constituted large swathes of the economy while utilizing relatively little technology and, in many respects, being little affected by industrialization.[10]

[7]For a good review of neoSchumpeterian perspectives with policy issues in mind see CHESNAIS, F. (1986). Science, technology and competitiveness. *STI Review* (OECD), No. 1, Autumn.

For more detail see several of the essays in DOSI, G. *et al.* (Eds) (1989). *Technical change and economic theory*. London: Frances Pinter. For a set of discussions of strategic issues broadly informed by this perspective, see GUILE, B. AND BROOKS, H. (1987). *Technology and global industry*. Washington, DC: National Academy Press.

[8]See MILES *et al.* (1988) for a forecasting study based on this account, which is derived from the work of Chris Freeman (1987) and Carlota Perez (1983) in particular. MILES, I., RUSH, M., TURNER, K. AND BESSANT, J. (1988). *Information horizons*. Aldershot: Edward Elgar. FREEMAN, C. (1987). The case for technological determinism. In: *Information technology: Social issues* (R. FINNEGAN, G. SALAMAN AND K. THOMPSON, eds). London: Hodder & Stoughton. PEREZ, C. (1983). Structural change and the assimilation of new technologies in the economic and social system. *Futures*, October, pp. 357–375.

[9]FREEMAN AND PEREZ (*op cit.*, Ref. 8) use the term 'technoeconomic paradigm', GERSHUNY AND MILES (1983) use 'sociotechnical system', while the French 'regulation' school use terms such as 'regime of accumulation' (for an English language account see Elam): GERSHUNY, J. AND MILES, I. (1983). *The new service economy*. London: Frances Pinter. ELAM, M. (1989). *A critical introduction to the post-Fordist debate*. Tema T Working Paper No 45, Department of Technology and Social Change, University of Linköping, Sweden. See MILES (*op cit.*, Ref. 5) for a discussion of the different emphases involved.

[10]On technology in services, see, for example, GUILE, B. AND QUINN, J.B. (1988a). *Managing innovation: Cases from the services industries*. Washington, DC: National Academy Press. GUILE, B. AND QUINN, J.B. (1988b). *Technology in services*. Washington, DC: National Academy Press.

Some general statistical problems

The urgent need for analysis of IT is related to this wide-ranging nature of IT-based change. There is considerable uncertainty as to how organizational and national competitivity can best be secured in this context, and the adaptability and innovativeness of firms and countries is a topic of debate. Information is required as to how the new technologies are diffusing, new applications are being forged and disseminated, and opportunities to change organizational structures and practices are being recognized and exploited. But the profound nature of the changes also renders empirical analysis more problematic in a number of ways.

As noted earlier, our statistical classifications were not developed with IT in mind: indeed, they were designed to suit the characteristics of earlier sociotechnical systems. With structural change in the economy, sectoral and product classifications are liable to inadequately capture new sectors and products. (The most interesting areas of growth are typically hidden away in categories with names like 'miscellaneous electronic equipment' or 'business services not elsewhere specified'. Similar problems arise with respect to new job categories.) Even more difficult problems arise, too, which cannot simply be resolved by adding new disaggregations to existing statistical systems. These stem from the blurring of established boundaries as organizational structures change, as different sectors converge with hybrid technologies, as difficult questions get raised about the nature of productivity and investment in an economy where information-processing is changing its role.

Another reason for seeking to maintain definitional flexibility is the rapid pace of change in IT itself: indeed, while IT is now very largely founded on microelectronics, it is not impossible that optronics will at some point take a leading role.[11] There is not even agreement as to the current definition of IT, with some authors including a broad span of communications technologies, others focusing on products of 'high tech' sectors, and others presenting a rather arbitrary collection of items (robots — but not aircraft flying on autopilot, for instance). This suggests that developments in statistical systems need to be undertaken in such a way as to ensure both clarity and flexibility. Definitions of IT products, sectors, occupations, etc. have to be spelled out explicitly, and ideally their conceptual basis will also be explicated. Our own perspective, derived from the analysis of technological revolutions presented above, is to relate IT to the use of a new heartland technology — microelectronics. But not all products incorporating microelectronics are themselves ITs: this would lead to the ridiculous situation that musical birthday cards and computerized jogging shoes (these really exist!) are ITs. Rather, we reserve the term IT for the heartland technology itself, and for those devices using its power to deliver information-processing functionality as their main product: i.e., computers and telecommunications equipment. But we recognize that there is still little agreement as to the best ways to conceptualize IT; thus data production systems should, ideally, allow for experimentation with alternative aggregations of the subcategories that are combined together.

One combination that it may often be useful to disaggregate is that of 'computers and telecommunications equipment'. Although IT is often defined as representing the convergence of these sectors and classes of products, the behaviour of the sectors and the diffusion of their products

[11]For instance, FALTAS (1988) remarks, 'while information and information-handling will no doubt become more and more essential to modern society, the continued dominance of electronics in the information business is in question' (p. 45). FALTAS, S. (1988). The invention of fibre-optic communications. *History and Technology*, *5* (No. 1), pp. 31–50.

still remain substantially different. Organizational convergence is less easy than the growing commonality of microelectronics and digitalization would suggest. At an interfirm level, joint ventures and efforts to integrate horizontally have been fraught with problems, and even within firms there are frequent cultural and organizational conflicts between the Data Processing and Communications functions.

The rapid pace of change around IT is reflected in no less than four more immediate problems — or four facets of one megaproblem — that are confronted by producers and users of IT-related statistics.

First, the last decades have witnessed the development of progressively more powerful IT facilities, while the devices in question have also simultaneously become cheaper, smaller, more robust, etc. A modern laptop computer has more memory than a roomful of hard-to-maintain, user-unfriendly gear did in the early 1950s. This improved performance is the basis for the wide diffusion of IT, of course, but it leads to statistical difficulties. As the example illustrates, the devices that are commonly defined as 'computers' can be very different things. Even more detailed classifications (e.g., into supercomputers, mainframes, minis, micros and embedded computers) run into the problem that, say, 1980s devices in each of the lower categories are functionally superior in many respects to 1970s (or even early 1980s) devices in higher categories. Similar problems confront many other specific ITs and IT-using technologies, making it difficult to be sure that one is comparing like with like. There is one bright point, in that the high rate of turnover of much IT equipment in many applications in Western countries, problematic though it may be for estimating capital stock statistics, does render cross-sectional comparisons rather more meaningful than they might be otherwise.

The second facet of this problem is probably more frequently encountered, since official data tend to be expressed in terms of money values rather than items of equipment. As is well known, the 'bits per buck' that can be purchased have been increasing dramatically: the costs of data processing, transmission, and storage have decreased as the capacity of chips, discs, and cables has increased. While improved efficiency and quality are common to much industrial equipment, the trends for IT are practically without parallel — and show little sign of slowing for decades to come.[12] Not only is a sum of money purchasing more IT power now than a short while ago: the growth in the quality of its IT purchases is higher than that for other industrial technologies. Thus, while it is possible to chart a growing IT-intensity of industry, by comparing the ratio of IT to other plant and machinery investment, the real growth in the application of IT is likely to be much larger (as is the increased centrality and criticality of IT in production). Again the problem is liable to be more acute for time-series than for cross-sectional analysis.

The third facet introduces the question of qualitative dimensions in IT development. Computers and communications are now being applied to tasks undreamed of by their pioneers. But, equally important, they are being applied in new ways, with the convergence of the two types of IT proving increasingly important. More and more, computers are being linked together through Local and Wide Area Networks to form new systems. For some commentators, this is actually the most important development in IT: the step towards 'systemation', toward a bridging of the islands of automation whose existence demonstrates that to date

[12]See MILES *et al.*, *op cit.*, Ref. 8.

only isolated parts of the overall production process have been reorganized using IT. The statistical problems such a trend poses are considerable: access to computer power is less likely to be associated with physical proximity of the computer; identical numbers of individual computers may be stand-alone systems or nodes of one or other complex network structure. What should we be counting: the units whose nature may be very different according to whether or not they are hooked up into networks, or the networks themselves, whose topology is becoming increasingly complex as distinct networks interpenetrate each other?

The fourth facet displays the eruption in the IT field of a problem that has long dogged our statistical systems. This is the overwhelming emphasis of such series on goods, hardware, manufactured products and so-called 'production industries' as compared to services, software, 'intangible products' and the tertiary sector. As is commonly recognized, *software and associated services* have been a steadily growing share of the total price of IT systems; and within this share, maintenance and related functions have been steadily growing at the expense of initial production of software. The programmability of IT — its real data-processing power — is nothing without programs, and the development of programs to exploit the growing power of hardware is a significant bottleneck, and a substantial (and productive) activity. Telecommunications equipment is used to yield *telecommunications services*, which have for a long time looked anomalous as compared to most other services on account of their technology and R&D intensity (although now more services seem to be joining them). A wide variety of new telecommunications services has been created in recent years, with the boundaries between hitherto distinct telecommunications services often becoming more blurred. And a variety of new information products, ranging from online databases to optical publishing, are becoming well established. Official statisticians have recognized the inadequacies of standard statistics to deal with such developments, and considerable effort is going into revision of the System of National Accounts and related data sets, at national and international levels. But events are moving much more quickly than the statistical apparatus.

The preceding paragraphs have listed a daunting set of problems confronting those who want to go beyond speculative generalizations about information society. They are problems being encountered throughout the industrial world, and a variety of efforts to overcome them are underway — although the 'information activity' approaches have resulted in some diversion of effort. The issues raised do provide plenty of scope for efforts to produce new data: for experimental studies by official and non-official agencies aimed at demonstrating the practicality of obtaining useful systematic information on IT-related topics. There have actually been a number of valuable studies of this sort: and, despite the problems, it is perhaps premature to despair of making use of existing data.

An overview of IT statistics

It was with these considerations in mind that a project entitled 'Mapping and measuring the information economy' was launched in Britain, under the auspices of the Economic and Social Research Council's (ESRC) Programme on Information and Communication Technologies

(PICT). Three research centres have been involved in this project: the Centre for Urban and Regional Development Studies at Newcastle University has been involved in studying regional and spatial dimensions of current changes, and the Centre for Communication and Information Studies at the Polytechnic of Central London has been studying features of the information and cultural industries. This paper draws on research carried out at the third centre, based at the Science Policy Research Unit (SPRU) University of Sussex, applying the 'neoSchumpeterian' perspective on technological change outlined earlier. (Locksley and Robins present research from each of the three centres.[13])

The aim of the SPRU study has been to critically review, existing statistics concerning the development and use of IT in the UK, to investigate opportunities for using these data, and to explore options for developing new statistics where these opportunities are limited. The remainder of this essay will focus on the critical review, outlining some of its conclusions concerning statistical data, their implications, and our needs for better data. It will only touch briefly on some of our efforts to utilize existing data, and on efforts to generate new data where serious absences have been identified. Finally, it will discuss only our studies of the civilian applications of IT, since a parallel project at SPRU is establishing a 'map' of the UK military IT field (see Walker,[14] for an early output of this work).

How far are the conclusions of the SPRU study applicable to other countries? While many features of the production and application of IT are liable to vary considerably, it is likely that many of the same shortcomings in statistics (and the opportunities to use available data) are presented in other countries. There are bound to be some peculiarities of the British: the situation in telecommunications data may be particularly difficult in that British Telecom has been privatized (and releases fewer data than when it was a state-owned concern) but retains an oligopolistic position in a commercially sensitive domain, for example. While our focus was the UK, we suspect that many of the points raised here would be echoed in other countries (for example, the paucity of data on software and services). Indeed, it might be well worth undertaking this sort of exercise in many more countries.

The full review of UK data and data sources has been published by the British Library;[15] it is rather lengthy and we can only hope to summarize some key points here. We set out to cover the broadest possible range of data, spanning the production, diffusion, application and implications of IT hardware, software, services and systems. The main data sources considered are official and academic sources; trade and press sources are also featured, but are relatively scanty; consultancy data are rarely featured in the review (in sharp contrast to their use in decision-making), on account of their generally combining prices and/or restrictions on use so high as to effectively remove them from the public domain, and details of methods of data production and topic definition so sparse as to effectively render them immune to serious (in)validation. (A few praiseworthy consultancy exceptions to these judgements are, however, featured in the study.)

A first, very general conclusion, is that a great deal of statistical data about IT does actually exist. These are, however, spread over a wide range of government agencies and research institutions, published in a wide variety of books, journals, conference reports, and the like. The

[13] LOCKSLEY, G. AND ROBINS, K. (Eds) (1990). *Approaches to the information economy* (provisional title), forthcoming. London: Frances Pinter.

[14] WALKER, W. (1988). *UK defence electronics: A review of government statistics*. London: Economic and Social Research Council (PICT Policy Research Papers No 4).

[15] MILES, I. *et al.* (1989). *Mapping and measuring the information economy*. London: British Library.

very act of bringing these together in one place is an extremely educational one, and it is hoped that the results will prove a useful guide to future researchers. A very few countries have attempted to publish 'social reports' concerning national IT issues — two noteworthy examples come from Sweden, a wide-ranging statistical study *Data om Informationsteknologin i Sverige*,[16] and a collection of telecommunications data issued by Teldok.[17] Organizing such reports is in many ways a complementary task to the more methodological type of review. The SPRU study surveys and assesses the data, only secondarily discussing what trends are depicted; the social reports focus on the latter, and necessarily omit some classes of data and data source.

A second very general conclusion is that many of the data that have been produced are surprisingly underutilized. While there are many grounds on which to be dissatisfied with available data, relatively few researchers seem to have attempted to see just how much can be extracted from it. This has not always been facilitated by the data producers, it must be said: the raw data from many studies has not been placed in the ESRC's Data Archive, and, indeed, in some cases the raw data have been coded in an idiosyncratic form for a particular computer system, and would take considerable effort to convert to a more standard form. But there are many other instances in which data are freely available for reanalysis, or where published data can be applied to new ends, and yet this has not been attempted. An example is the use of input–output tables to describe the pattern of investment in IT products: a US study is frequently cited,[18] but parallel data in Britain and elsewhere have remained largely unexplored.

A third set of conclusions has already been mentioned. Available data tend to be directed along rather circumscribed tracks, especially in their focus on hardware as opposed to software and services. Repeatedly we find, for example, that production and trade of computer hardware is treated more exhaustively than that of software, that computer and telecommunications equipment production and diffusion are better treated than are telecommunications services; that the use of IT in manufacturing (and within that, in production processes) is awarded numerous studies, while relatively few consider services (and administrative work). And data on applications and activities — what people actually do with IT, and what their experiences with it are — are frequently weak.[19]

A critical review of UK statistics and sources

The SPRU review contains seven chapters detailing specific areas of data. (An additional three chapters introduce and summarize the issues, and discuss the characteristics of data sources and the conditions of production of data, and how these affect the scope for change in statistical practices.) This section briefly summarizes some of the main points arising in the seven substantive chapters.

Research and development

This chapter reviews data and data sources covering:

1. Pure research and science (including data on employment and expenditure, as well as 'output' measures such as bibliometrics).

[16] STATISTIKA CENTRALBYRÅN (1988). *Data om Informationsteknologin i Sverige*. Stockholm: Statistika Centralbyrån.

[17] TELDOK (1988). *Teldoks Årsbok supplement 1988*. Farsta, Sweden: Televerkets hk, Teldok.

[18] ROACH, S.S. (1988). Technology and services sector: America's hidden competitive challenge. In: Guile and Quinn, 1988b, *op. cit.*, Ref. 10.

[19] A notable exception to this is a Finnish study based on a large-scale sample of the workforce: KORTTEINEN, M., LEHTO, A-M., AND YLÖSTALO, P. (1981). *Information technology and work in Finland*. Helsinki: Tilastokeskus, Central Statistical Office.

2. Government financial support for R&D, in general and for specific programmes of research.
3. Industrial R&D funding and activity.
4. Studies of innovation as indexed by patenting and other measures.

There are many data available, but one particular problem is frequently encountered: R&D activities are classified in such a way that it is often difficult to identify specifically IT activities (although innovation data clearly demonstrate the growing significance of these activities). The IT hardware producing sectors are relatively well covered in R&D statistics. Software and related activities tend not to get classified as R&D (they may appear in research programmes, however), a fact now recognized by the OECD which is considering appropriate revisions to its Frascati manual for R&D measurement.

Production of IT

The point made above concerning the relative emphasis of statistics on hardware as opposed to software and services again appears in data on the employment, output and trade of IT equipment producing sectors. In keeping with our definitional discussion earlier, these are taken to be the semiconductor producers, and the main direct users of their output, computer and telecommunications equipment manufacturers. Various issues of *Business Monitor* cover these and related branches of activity, such as electrical instruments, radio and electronic capital goods, etc. (As noted, this study distinguishes between *IT products* that use the new technologies with information processing as their primary function, and *IT-using products* which apply IT power to augment or facilitate other primary functions, such as transporting or manipulating goods or materials.) In many respects the IT hardware sectors are exemplary parts of the national economy, with high output and productivity growth: but employment and trade performance are more ambigious. There are less detailed, but relatively good data on the computer services sector, and on some aspects of telecommunications services, although newer services are proving a problem for official and unofficial statisticians alike.

Diffusion of IT

Input-output tables can be used to give some measure of sectoral expenditure on IT hardware, and it is interesting to note that, while service sectors are aggregated relatively grossly compared to other branches of the economy, they still manage to be responsible for some 80 per cent of UK investment in computer and telecommunications equipment. These tables also show that such equipment takes up a large share (almost a quarter) of all plant and machinery investment. The technological revolution appears to be progressing rapidly, and to be particularly concentrated among service sectors. Ironically, however, services are treated in a gross aggregation in the tables, both as producers and users of IT. Thus the tables are not very helpful as to software and computer services, although the 1984 version does at least distinguish telecommunications services from post!

The 1986 *Census of Production* provides rather more detailed information on computer hire, expenditure, and employment across (non-service) sectors of the economy.[20] (Interestingly, our analyses suggest that computer investment in manufacturing is highly correlated

[20]For an account, see MEHTA, A. (1989). Diffusion of computers. *British Business, 10* (February), pp. 30–31. Data for 1988 are also being prepared.

with the extent of internal service activities in manufacturing sectors.) There have also been a number of valuable academic studies of the use of microelectronics across manufacturing sectors.[21] We were able to locate only one academic survey of IT use in (private) services,[22] and one survey that spanned the whole economy (but this was limited to establishments of more than 25 employees, and which will thus underrepresent small service establishments).[23] Most studies concern the use of hardware: the use of software and services is rarely addressed. The studies of microelectronics in manufacturing (which do not consider office/administrative applications), which have been replicated in a number of other countries, centre on diffusion issues. Otherwise, none of these studies, surprisingly, has been subject to much attention as a source of material for examining diffusion patterns. But it is clear from all of them that IT is diffusing with remarkable rapidity across many sectors of UK industry.

Application areas

This chapter considers both certain IT applications (e.g., robots, office equipment) where data exist — often from trade sources — and it also deals with statistics covering limited sectors of the economy. It notes that statistics on major applications are often dogged by definitional issues (what is a robot? a Flexible Manufacturing System? a word processor?) which are aggravated by (a) the rapid pace of technological change, (b) the 'convergence' of hitherto discrete technologies, and (c) 'hype' from suppliers and traders who seek to classify their products in terms of the latest buzz words. One of the few areas of telecommunications where regular and rich data are available — the quality of public telecommunications services, a 'hot' political issue — is also treated here. Probably the most significant and certainly the most substantial of the sectoral data concern the use of IT in central and local government, where rather rich data are available on IT expenditure and employment, where a number of agencies and watchdogs are active in monitoring activities and providing advice. Government administration was an early user of computer systems, so the experience accumulated here is considerable — despite the 'leakage' of many key staff to the more lucrative private sector.

Work and employment

While official occupational classifications do define a large number of IT-related jobs, employment data are more generally reported by industrial group, and censuses that could yield detailed information on the distribution of IT occupations (programmer, systems analyst, telecommunications manager, data entry operative) are infrequent. Several organizations do, however, provide estimates on IT professional staff numbers, with a particular interest in assessing and forecasting skill shortages, which are generally supposed to be acute (although there is some dispute about how far this a general problem, and how far one specific to particular regions, sectors and skills). The chapter considers a wide range of surveys on these topics, together with surveys tackling pay and recruitment themes; there are also by-product statistics on a variety of education and training schemes. Studies concerning organizational change associated with IT remain relatively rare, but there are several surveys of worker attitudes to, and industrial relations around, IT-

[21]For a recent overview see NORTHCOTT, J. with WALLING, A. (1988). *The impact of microelectronics: Diffusion, benefits and problems in British industry*. London: Policy Studies Institute.

[22]See YAP, C.S. (1986). Information technology in organisations in the service sector. Dissertation submitted to the University of Cambridge for the Degree of Doctor of Philosophy, Downing College, Cambridge. YAP, C.S. AND WALSHAM, G. (1986). A survey of information technology in the UK service sector. *Information and Management, 10*, pp. 267–274.

[23]For a study using these data, see DANIEL, W.W. (1987). *Workplace industrial relations and technical change*. London: Frances Pinter.

related change: one senses that researchers have been rather surprised by the relative lack of conflict.

Final consumption

Both market research and some academic and official surveys have provided statistics on the diffusion among consumers of a number of types of IT product, with home computers having received probably most attention. A few sources go beyond the mere fact of purchase to provide some information on patterns of use, and it will probably come as no surprise to learn that even if the level of diffusion of home computers is particularly high in the UK, the predominant uses tend to be for entertainment (video games). Market research studies dominate this area, although their broad results are often released into the public domain. It can be anticipated that with the development of new ranges of IT-based products, and the use of microelectronics within many familiar items of household equipment, the analysis of consumer use of IT will require more detailed academic studies than are available to date.

Social implications

A large number of topics could, in principle, be addressed under this heading. In actuality, the study was only able to identify three topics where statistics have been developed to any extent, and it is to be hoped that more effort can be addressed to the broader social aspects of the 'IT revolution' — for instance, such questions as political power, distributional issues, etc.

The first of the three topics was *social attitudes to IT* as assessed by opinion poll and attitude survey; there have been a number of such studies, some of them comparing attitudes across different countries. They demonstrate generally high levels of acceptance of IT, especially among younger people, although there are reservations concerning application of technology to some areas of everyday life, and mixed reactions as to unemployment, retraining, etc. While interesting, these studies are generally not very impressive as to the style, scope and depth of questioning.

Where *data protection and privacy* issues are concerned, some statistics are available from the Data Protection Registrar, concerning the databases holding personal data, their purposes, and as to organizations' knowledge of the scope of data protection law and their responsibilities under it. The limitations of these statistics mainly concern the absence of structural analysis of organizations holding such information, and the related topic of interchange of non-stored information between organizations and between IT-based and non-IT-based retrieval systems.

Computer crime is a 'hot' media issue, and one where there are very real risks, but where commentators note that victims may often seek to minimize the problem, while, in contrast, certain experts may be concerned to 'talk it up'. The few surveys that exist of the topic suggest that the prevalence of serious fraud is less than is often believed, but the studies are limited both in scope and methodological adequacy.

Thus, for these three types of social implication of IT use, the available data are thought-provoking rather than definitive. Only studies in the data protection area are regular ones (being in part based on administrative by-product data). There is considerable scope for

further research on social implications, but there are few guidelines to follow in this vast area. The terrain remains wide open for speculation of the sort discussed at the beginning of this essay.

Conclusions: the (mis) information age?

Our review of available data identifies numerous limitations in existing statistics concerning IT activities, and a lack of enthusiasm among social researchers to exploit what is on hand. No doubt these factors contribute to the vapidity of many of the efforts to present general overviews of the 'information society'. Unable to impose much order on the bewildering diversity of case study results, commentators fall back on generalities or on the banal prejudices of technological optimism and pessimism. It is hoped that critical review efforts, perhaps building on the effort outlined here, can contribute to a raising of the level of debate. This is particularly important, given the rapid diffusion of IT that can be clearly demonstrated in existing statistics.

It is also hoped that such reviews can help point to areas where statistics might be improved, and to specify how improvements might be achieved. Some of the shortcomings in available data seem to reflect conceptual problems (how to define and measure various new products and activities); others derive from historical and institutional factors (the lack of attention to services, and to use of telecommunications). At SPRU we are undertaking a number of original survey and database studies which are intended as steps toward filling in some of the gaps in knowledge: including surveys of the use and production of software throughout the economy (i.e., not just in the computer services sector), of private videotex service providers, of the use of online databases, and of corporate telecommunications use.[24] While our resources are limited, it is important that efforts to produce relevant new data be undertaken. In many instances they may best be conducted by independent groups on an experimental basis (though hopefully with assistance from official statisticians). Wider discussion as to information needs among social scientists, policymakers and the business community is sorely needed.

It is also desirable that data that have been produced should be made more widely available for reanalysis. While appreciating that there are problems of intellectual property, it should not be too much to ask that consultancy reports on which large sums of public money have been lavished should be placed in the public domain, where there would be more scope for independent analysis of their methods, data and conclusions. While ESRC-funded academics are strongly encouraged to place their raw data in the Data Archive, some of the most interesting studies have not been conducted under ESRC auspices: perhaps funds for data conversion might be appropriate? In general, existing data should be more widely publicized: perhaps an occasional omnibus of IT-related statistics would be a good idea, and it would certainly be valuable to have more discussion of the efforts and achievements of different countries in producing IT-related data.

IT is associated with many different kinds of change. Many early forecasts which attempted to identify global features of IT-related change have foundered on the diversity of empirical experience: some jobs are upgraded and some deskilled, both centralization and decentralization seem to be developing, major applications have typically taken off in a very uneven way, and so on. As we have seen, there is even

[24]Tim Brady is responsible for the software survey, Nick Jagger for work on videotex and online services, and Asu Aksoy for studying corporate telecommunications use.

considerable scope for debate as to how IT should be defined (only technologies based on microelectronics? but what then is software?), whether and how we can distinguish between IT products and IT-using products (should the television set be regarded as IT? the microprocessor-controlled car — which may well have more electronics in it than the average home computer?), and the like. At present, there is little consensus on these topics.

The approach to such issues summarized above is being elaborated more fully in our ongoing research; but we recognize the value of continuing debate on such issues, for no research group has a monopoly of knowledge, and different approaches may be appropriate for different research questions.[25] Thus, it is important to stress the need to foster dialogue and experimentation around different statistical approaches, to keep data sets in forms which enable the application of alternative approaches to aggregation and analysis, and to avoid premature commitment of resources to what may turn out to be a transitory crystallization of phenomena, or a short-lived agreement as to definitional issues. It is possible to see elements of the new information system, but at this moment in time there are no complete answers available. A system of 'satellite accounts' may be the best we can expect from official statistics for some time to come.[26]

Paraphrasing Marx, people may make their own history, but they do not do so in circumstances of their own choosing. The information society is being constructed, but our understanding of it is largely being constructed with intellectual tools forged in earlier industrial eras. This is bound to lead to failures in analysis, judgement and strategy.[27] Better data will not provide all the answers, by any means, but with poor data appropriate answers will be harder to find. (We may not even ask the right questions!) We need discussion and debate that is as wide as possible on the information needs for the information age.

[25]For example, while an analysis of technological revolutions is important in considering relations between social and technological transformations, it would not capture all of the important developments — such as the contraceptive pill!

[26]For a discussion of satellite accounts, see TEILLET, P. (1988). A concept of satellite account in the revised SNA. *Review of Income and Wealth*, Series 34 (No. 4, December), pp. 411–439. Cf PRESTON, P., who also discusses some topics touched on in this essay: PRESTON, P. (1989). *The information economy and the International Standard Industrial Classification (ISIC): Proposals for updating the ISIC*. London: Economic and Social Research Council (PICT Policy Research Papers No. 6).

[27]BLOCK, F. (1985). Postindustrial development and the obsolescence of economic categories. *Politics and Society, 14* (No. 1), pp. 71–104.