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Mechanisation, computerisation and information systems

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Overview

This chapter examines the effects of technical innovations in record keeping on accounting and the nature of accounting work. There is no clear-cut periodisation of the changes in technologies but, for convenience, changes are dealt with in four overlapping eras. The first era covers the period of increasing mechanical aided recordkeeping from the mid-19th century until about 1930. The second period looks at the changes from the Second World War until the early 1970s arising from the early introduction of digital computing into the business sphere. The last three decades of the century, when computing became established as the prime mode of business record keeping and the personal computer (PC) revolution took place, represents the third era. This epoch blends into the final era when the combination of the Internet and highly integrated systems change the nature of business operations as well as the recordkeeping of which accounting is a part.

One of the reasons for a lack of clear periodisation is that not all businesses, or all accounting practices, changed at the same rate or in the same ways. There were clear sectorial differences in all periods, in several dimensions, as well as geographical differences in part influenced by levels of economic development. In this context, the periods discussed are mainly from the developed Anglo-Saxon and European perspective. Additionally, various degrees of delay and inertia operated with the result that, even in the later, more technically advanced, periods, some organisations continued to use systems from earlier eras though possibly for good (economic) reasons. Indeed it is likely that even today there are small organisations using little technology, and some not keeping accounting records at all.

The chronological study of accounting technologies is then shown to be central to the transformation of the ways in which accounting and accountants operated. Beyond these first order changes, the technological changes have, partly through lowered processing costs and increased process and commination speeds, facilitated growth in the scale of business operations and led to more information for decision making and control. It is clear that the technical changes discussed in this chapter have created opportunities and threats for accounting firms and for accountants, both within public practice and the commercial or public sectors. Some of these changes are explored, including; the effects of lack of 'paper trail' on the audit process; the opportunities for accounting firms to broaden their scope of business consultancy; the separation deskilling and feminisation of bookkeeping; and threats from new technologies.

The chapter concludes with a review and reflections on the further development of information systems in accounting and their impact.

Introduction

> The scope of AIS [Accounting Information Systems] has expanded throughout history with the role of accountants, and as a consequence technological development has shaped how accountants perform their work.
>
> (Rosati and Paulsson 2018: 13)

This chapter is concerned with that history, and in particular of accounting and the mechanical and computing technologies that have shaped it, in effect, over the last two centuries. The changing nature of what is seen as accounting makes any tracing of its history problematic and, as modelled by Mauldin and Ruchala (1999), it is important, in the context of what accounting has become, to consider a range of cognitive and organisational issues as well as the technical to have a sound perspective on that history. In the related field of general Information systems research Hassan (2018: 17) notes that:

> IS historical studies require a balance that combines social organizational concerns with technological concerns, and ideally addresses questions about some major historical event.

Reflecting the content of the existing literature, the focus of this chapter is principally on technical change although some broader, organisational and social concerns will be addressed.

The mechanical accounting era

The background to mechanical accounting

Until the late nineteenth century, accounting was a manual process. Generally, at least in the West, transactions were entered by hand into large bound journals or day books and then posted by hand to bound ledgers. As the closing process could be time-consuming not all businesses closed their accounts or produced financial statements on an annual basis. As Yates (1985: 144) points out, owners were usually involved in their companies' day-to-day operations and had direct knowledge of their financial conditions.

With the emergence of new, large and geographically diverse corporations with management more separated from ownership, the demand for information accelerated. Chandler notes (1977: 19) that, for these large companies to succeed, an increased flow of information to both managers and owners was necessary. As this demand increased, the first major innovations in information processing also occurred (Yates 1991).

The first mechanical devices

De Wit *et al*. (2002: 69–70) point out that machines are often introduced with one purpose in mind, but their functions normally expand. This was the case with the typewriter which, invented to aid the writing process (e.g. E. Remington & Sons type-writer in 1873, Bliven 1954: 42–56), became the predecessor of the bookkeeping machine as businesses found it useful in preparing invoices and reports, especially if they used pre-printed forms containing standard information (Yates 1991: 122). To aid this process businesses standardised reporting and document preparation practices and, with this greater uniformity, the analysis of information became easier (Yates

1994: 32). With typewriters, prepared forms, carbon paper, and standardised reporting, the cost of information processing noticeably dropped (Page 1906).

In 1891, with the introduction of the 'book-typewriter', a typewriter modified to accept bound books and generate multiple carbon copies, an accountant could enter a transaction directly in a bound journal or ledger and create multiple-copies of invoices (Moore 1932: 57).

One of the first successful commercially used calculators in Europe was the Thomas Arithmometer, developed in France in the 1820s and generally available from the 1850s. So successful was the Arithmometer, along with other European designed machines (e.g. the Odhner in 1873 and the Brunsviga in 1892), that were used (with improvements) for nearly a century (Cortada 1993: 27–8). However, in the USA, the Thomas Arithmometer was little adopted early on, and most computations continued to be performed manually until the turn of the nineteenth century.

In the late 1880s, Dorr Eugene Felt developed a key-driven calculating machine called the 'Comptometer' (Turck 1921: 75) which could add, subtract, multiply and divide. During the same period, William S. Burroughs introduced a recording/adding machine that provided a record of transactions. These machines had an immediate effect on accounting. Addition was such a major part of accounting that George Seward (1904: 607), writing in the *Engineering Magazine*, estimated that 95 per cent of accounting work in a factory could be attributed to that task. Given the increased speed and accuracy with which accounts could be totalled using these machines, preparation of trial balances became more common and the determination of unit costs, and data analysis generally, became a simpler process. Whereas, previously, many companies did not analyse financial/managerial data because of the time involved, this drawback no longer applied (Galloway 1919: 83).

The introduction of the Arithmometer and the Comptometer relegated many office practices to routine operations. Until the late nineteenth century office clerks were often considered the 'predecessors of modern middle management' (Cooper and Taylor 2000: 561), with the collection and computation functions related to financial data handled by an accountant/bookkeeper considered skilled tasks. As the processing of information became more routine, repetitive and mechanised, the tasks and the people performing the task became 'deskilled', and with deskilling came lower wages (Cooper and Taylor 2000: 556–8). As the cost of processing information fell dramatically it became more cost effective to meet the demand for more information, and companies began to hire women for these roles as they were paid substantially less than the men they replaced.

More early innovations in information processing

From bound volumes to loose leaf

As the size of companies increased and the number of transactions multiplied, the deficiencies of bound books became more apparent, and towards the end of the nineteenth century these were gradually replaced by loose leaf accounting systems. Early versions include those developed by the Baker-Vawter Company in the USA in 1896, and at about the same time by Andreas Tengwall in Sweden, which was distributed by the Krag Manufacturing Company in the USA (Wootton and Wolk 2000: 87–9).

Some businesses and accountants were reluctant to adopt loose leaf systems and in some countries bound volumes were required by regulation (see Chapter 5). Security of records was a major concern. In publications such as *The Accountant*, articles and letters were published on the merits and weaknesses of loose leaf systems. A common criticism was that, since pages could be easily removed from the volume, it would encourage dishonesty which in turn would be harder to detect. Those in favour of change, by way of contrast, cited the new systems' greater flexibility and efficiency (Dicksee 1911: 652–7). This debate, and how to overcome the systems' weaknesses (Aspray 1917: 311–13), continued into the early 1920s. One feature of the system that received considerable attention in *The Accountant* was the use of slips for postings (Price 1902: 9–18); instead of posting the ledger from the journal, the preparation of the slip (sales invoice, bank deposit slip) served as the original entry from which the ledger was posted ('Slip' or 'card' bookkeeping 1902: 1069–72). Over time, the systems' advantages slowly began to be recognised. For example, the Post Office Savings Bank in Britain evaluated the loose system in 1908–10 but rejected it because of security concerns. Not until 1925 did it finally adopt a card-based ledger (Campbell-Kelly 1998: 23–9).

Tabulating, billing and duplex adding machines

During the early twentieth century another major mechanical innovation gained ground – the tabulating machine. The tabulator was the computation element of a three-part tabulating system – the others being the card punch machine and the card sorter. In companies where vast amounts of data were processed, the tabulator quickly found acceptance. Railroads recognised its utility for freight accounting, for example the New York Central processed more than four million waybills using a Hollerith tabulator in 1897 (Norberg 1990: 762). Railroads also discovered that they could replace an expensive accountant with a clerk or bookkeeper to handle data entry. Recognising the economic value of tabulators to their users, manufacturers normally refused to sell the machines but would instead lease them, guaranteeing continuous cash inflow.

Another useful innovation was the billing machine which combined typewriter and adding machine, allowing a bookkeeping clerk to prepare an invoice and post the transaction to the ledger at the same time. It was claimed that the Elliott-Fischer billing machine, at $325 (A billing and adding machine combined 1906), was cost effective given that a billing machine operated by a single clerk could often replace two accountants.

The 'duplex' adder was another innovative aid to the accounting process. These had two adding wheels and could transfer amounts between the wheels, allowing them to perform two operations at once, for example they could record both cost and retail price at the same time and keep track of the payroll of individual departments while determining the total payroll. The Burroughs Company offered a duplex, from 1910, that could record employees' earnings on individual payroll envelopes while it recorded the payroll sheet (Lewis 1914: 179–88).

Growing acceptance of mechanical accounting

As the capabilities of bookkeeping machines rose, their use gained growing acceptance in Europe as well as in the USA. Early on tabulator usage was restricted to a few large insurance companies and railroads. By 1920, the market for tabulating machines was international and users included large manufacturers and retail firms. In the USA companies including Marshall Field and Eastman-Kodak used tabulators in cost and sales analysis and inventory control (Strom 1992: 181–2) and the textile industry

became a leader in the use of the tabulators in payroll, stock control, dispatching, and standard costing (Norberg 1990: 772–3).

In Europe, the tabulator also found widespread application. Rotterdamsche Bankvereeniging (Robaver Bank) installed a Hollerith system to handle its giro department (de Wit and van den Ende 2000: 97). By 1923 the Prudential Assurance Company (UK) had in operation a Powers Tabulating System including 35 tabulators, 24 sorters, and 100 card punches (Campbell-Kelly 1992: 131). Prudential also acquired the British rights to manufacture and distribute the Powers machine throughout the British Empire. At one time, its punch card machine held nearly 50 per cent of the British market (ibid.). Also both Société Générale and Banque Générale du Nord achieved significant cost efficiencies by utilising bookkeeping and calculating machines (Bonin 2004: 266–7). This mechanisation of bank accounting reduced jobs and costs and led to increased centralisation of record processing activities (ibid.: 269).

From the 1920s the cost of business machines fell. For example, the Victor Adding Machine Company introduced a machine costing half the price of comparable machines (Darby 1968: 29) and, in competition with the widely used Comptometer companies, began to market electric calculators such as the Monroe Calculating Machine Company's Model K electric calculators (Martin 1925: 250–1). With lower costs, most large businesses and many small ones employed some form of mechanical accounting to record information and to reduce the manual aspects of accounting by 1930.

Mechanisation changed the nature of the tasks required of a bookkeeper, which came to be perceived as more repetitive and menial and less managerial. The resultant feminisation of the workforce increased and further relegated to the status of bookkeeping as a technical trade whilst accounting was evolving into a profession (see Chapter 11). This transition was encouraged by the ability to pay women lower wages and by a shortage of white middle-class males. From comprising only one per cent of the bookkeeping workforce in the USA in 1870, women accounted for 63 per cent of the bookkeeping workforce by 1930. The established professions, at this time, remained male dominated (Perks 1993: 11). In contrast to bookkeeping, in 1930, only 9 per cent of accountants were women, and this percentage did not notably change until the early 1960s (Wootton and Kemmerer 2000: 172).[1]

The general acceptance of mechanical accounting that had occurred by the Second World War was not without controversy. In 1949, a report was issued by the Mechanised Accounting Sub-Committee of the Taxation and Financial Relations Committee of the Institute of Chartered Accountants in England and Wales. The report stated that, while mechanised accounting seemed to be nothing more than a change in the way information was processed, in reality mechanisation sometimes resulted in the loss of documentation without a 'compensating' increase in the information required for an audit (ICAEW 1949: 14). The Report also emphasised that the company and the auditor should work together at all stages of mechanisation – from the selection of machines to the determination of records to be mechanised. The Report set out steps that a company might take to make the examination of mechanised records easier and it reminded the auditor to exploit the potential of mechanisation as an aid to the audit process.

[1] Feminisation of the workforce of clerks and bookkeepers in Britain over a similar time period is studied by Kirkham and Loft (1993).

Transition from mechanical to computerised accounting

The first computers and transition of accounting processes

For nearly thirty years following the general acceptance of mechanical accounting in the early decades of the twentieth century, few radical innovations occurred in processing accounting information. Computers and increasing scale of businesses were the next catalyst of change. Charles Babbage is considered the inventor of the (analogue) computer in the early nineteenth century. Alan Turing invented the principle of the modern electronic computer in 1936, but his design was not developed until after 1945 Copeland (2017). The Second World War acted as a catalyst to the development of the first fully functioning electronic digital computer, COLOSSUS, by British Intelligence: a huge 'main- frame' computer which came into operation in December 1943 (Shurkin 1984: 140–3). Similarly, in the USA, there was a push to develop a machine that could process vast amounts of mathematical information resulting in the creation of ENIAC.

The effects of computers on accounting was to become significant, but was far from instantaneous or universal. For a further two decades mechanical and computerised systems were being developed and used. Further, in sharp contrast to early predictions that around ten large computers would satisfy the USA's entire business needs (Sanders 1968: 28), the need to efficiently process financial information became a catalyst in the expansion of the computer's use. By the mid-1960s, studies found that nearly 50 per cent of a computer's time was used to process accounting-related information (Li 1968: 12). As computerisation became more universal use of mechanical systems began to decline.

Early years of business computerisation

> J Lyons & Co were amongst the world's leaders in office management systems… As they grew rapidly in size in the early part of [the 20th] century … they had to deal on the accounting side with an enormous number of very small individual transactions.
>
> (Hendry 1987: 74).

In 1947, Lyons – in particular John Simmons – recognised the potential of electronic machines to process business data and, in conjunction with a team from the University of Cambridge, worked on developing a computer that could handle accounting tasks (Hendry 1987: 75; Ferry 2003: 34–70). The computer, LEO which stood for Lyons electronic office, was commissioned in 1953 and was soon processing payrolls for a range of companies including the Ford Motor Company (Ferry 2003: 111,149). Two years later LEO became 'the heart of [Lyon's] ordering and distribution system' (ibid.: 129) and was so successful that Lyons set up a separate company (Leo Computers Ltd) to exploit its commercial potential. LEO and its successors were recognised as 'ground-breaking' machines (ibid.: 166). However, its development and marketing required vast amounts of capital at a time when teashops were in decline. In 1963, Leo Computers merged with English Electric. Although LEO III was comparable (maybe superior) to the IBM System 360, the introduction of the 360 and IBM's vast resources hastened the demise of LEO which ceased production in 1967 (ibid.: 184–95). Despite justification of the use of LEO to save clerk labour, Haddy (1958: 164) notes that Lyons employed more staff after installation, than before, as the 'amount of work done has greatly increased' .

The General Electric Company purchased a Universal Automatic Computer (UNIVAC) to process business information at its Appliance Division just three years after Remington Rand's first UNIVAC Computer was used at the US Bureau of the Census in 1951 (Li 1968: 5). Arthur Andersen & Co. had recommended the UNIVAC to General Electric as a part of an accounting system it was installing (Spacek 1989: 176–7), an early example of the involvement of an accounting practice in computer consultancy, and a key element in their practice development (ibid.: 197). However, at this time the computer's future in accounting did not seem particularly bright: according to Spacek, Learson (head of sales at IBM) stated that 'there was no future in the accounting field for computers' shortly after the GE installation (ibid.: 136–7).

In 1953, a significant breakthrough occurred when IBM introduced its 650 Magnetic Drum Data Processing Machine. Included in the accounting functions were payroll processing, actuarial computations, customer billing, and branch store accounting (650 applications n.d.). The first IBM 650 was installed in the controller's department of the John Hancock Life Insurance Company in Boston (650 chronology n.d.), and nearly 2,000 were retailed by 1962 (IBM 650 n.d.). In 1957 the IBM 650 was first used in Europe, led by the Dutch Land Cultivation Company's purchase (de Wit *et al*. 2002: 65).

In 1956, IBM announced its 305 RAMAC and 650 RAMAC (Random Access Method of Accounting and Control) computers, claiming they would revolutionise office procedures. More specifically, given their random access memory (RAM), accounting could be a 'continuous' process with data entered and retrieved nearly instantaneously. The RAMAC remote feature allowed accountants in other offices to check sales figures and determine the level of current inventories (650 RAMAC announcement n.d.).

In Germany, for example, computers were also finding greater use in accounting. Heinz Nixdorf founded the Heinz Nixdorf Company and, by the mid-1960s, had sold 5,000 small computers specially designed to perform daily accounting functions. The company's success in Germany encouraged the Victor Comptometer Corporation to sign a marketing agreement which allowed it to sell (under the Victor name) the computer in the USA and Canada. An advantage enjoyed by the Victor Comptometer Corporation was that its computers were priced significantly lower than the larger IBM mainframes (Darby 1968: 217–19).

Hybrid accounting technologies in the decline of mechanical accounting systems.

In 1962 IBM introduced the hybrid electronic/mechanical 6400 Magnetic Ledger Accounting Machine. Through the use of magnetic tape enhanced cards, the 6400 combined electronic storage with visible text and could handle billings, inventory, accounts receivables, payroll, and general accounting (New: the IBM alpha-numeric magnetic ledger card 1963: 5). Both Frident's 6010 (Frident 6010 electronic computer 1963: 14) and General Electric's GE-225 (Computer progress at General Electric 1963: 26) had similar features. However, their cost was significant ($4,000 to $10,000 per month (Announcing the GE-215 1963: 10–11).

Also in 1962, the Bank of America implemented its ERMA (Electronic Recording Machine Accounting) system. This was an historic attempt to change the ways cheques were processed, recorded, and chequing accounts updated. Instead of the customer's name, as had been used for a century, the system used a magnetic ink character recognition (MICR) account number printed on the cheques to facilitate their sorting and processing. The MICR system soon became a standard in the banking sector both in the USA and elsewhere. By 1962, ERMA was handling more than 2.3 million of the Bank

of America's cheque accounts, resulting in the elimination of 2,332 jobs for proof and transit operators and book- keepers (McKenney *et al*. 1997: 332–5). MICR cheque systems have evolved and are still in use, but other elements of the mechanical accounting systems soon became uneconomic compared to the emerging computer based systems.

Widespread electronic data processing and computerised accounting

Electronic data processing (EDP) and the computerised accounting systems

This section covers the last three decades of the twentieth century, the period during which the use of computers became almost ubiquitous in the processing of transaction data and in the maintenance of accounting records. By the early 1970s, the cost of a computer had dropped significantly, for example an IBM System/3 minicomputer could be rented for around $1,000 a month (Ceruzzi 1998: 158), though many organisations were still using mainframe computers for EDP purposes during this period.

In three years following its launch in 1983, IBM sold 100,000 System/36 minicomputers (IBM System/36 n.d.). These, and other 'mini' computers became, an ideal substitute for expensive mainframe computers for smaller businesses. The variety of systems in use varied substantially. Many organisations used bespoke or adapted systems, though standardised/packaged systems were more prevalent towards the end of the period (Hirschheim and Klein 2011).

The advantages of computers lay in areas involved with the processing of large volumes of data. In accounting, therefore, sales, purchasing and/or payroll systems, depending on the nature of the business, along with their associated payments and receipts transactions were most commonly computerised, at least in the initial phase. The use of general (nominal) ledger-based EDP systems also became more prevalent, though in many case these were largely separate from the operational/transaction and report generation systems (Rosati and Paulsson: 2018).

Personal computers, lower costs and new software

Personal computers began to be available in the mid-1970s and became a major influence on business computing and accounting at the start of the 1980s. IBM entered the market with the IBM 5100 Portable Computer range which, though barely 'portable', were at least movable (IBM 5100 portable computer n.d.). IBM marketed towards business and accounting uses, with the inclusion of application software encompassing billing, inventory control, accounts receivables, sales analysis (IBM 5110 n.d.) and, later, payroll and general ledger accounting (IBM 5120 applications n.d.; IBM 5120 c.1980).

However, the most successful family of micro-systems in the late 1970s were CP/M operating system based PCs of many makes (Bresnahan and Greenstein: 1999). The CP/M Osborne 1, of 1981 is also widely credited as the first really portable, or at least 'luggable', PC. It was in use at Peat, Marwick, Mitchell & Co. (now KMPG) in London in c.1982.[2] Apple systems eventually ranked second towards the end of the period (ibid.: 13). It was in these environments that the spreadsheet revolution, that has had such a major effect on accounting ever since, took place: Visicalc on Apples in 1979 and Supercalc on CP/M in 1980 (Mattessich and Galassi 2000).

[2] Personal experience of Greg Stoner, joint author.

IBM introduced their PC in 1981, with a US price of around $1,600, making the computer attractive to smaller businesses (The IBM PC's debut n.d.). The PC (IBM and compatible computers) was to become the dominant PC platform in business use for several decades, fuelled in many respects by the availability of spreadsheet software. Supercalc running under DOS (Disk Operating System) in 1982 was an immediate success, with more than 100,000 copies sold in the first year. Three years later, the more powerful and faster spreadsheet, Lotus 1–2–3, package was introduced. Costing just $495, more than 800,000 copies were sold in eighteen months (Campbell-Kelly and Aspray 2004: 134). Lotus dominated the spreadsheet market into the early-1990s. However, ultimately Microsoft's Excel (which had started on the Mac platform) took control of that market (Campbell-Kelly 2001: 131), helped by the move of PCs from DOS to Windows.

The availability of a spreadsheet package made the emerging PC more attractive to users, especially accountants, as their relatively low operating costs enabled then to break away from the control of corporate information technology (IT) departments.

By the late 1980s the computer had secured its place in processing accounting information, PCs were in widespread use across organisations utilising accounting data (sometimes accessing central systems data) in decision support systems of various types, and the spreadsheet and PC had become the ubiquitous tool of the accountant.

Systems integration: the beginnings

In the mid/late-1990s, the integration of separate operational and accounting cycle systems and between PC and central systems became more common (Rosati and Paulsson: 2018), developing the notion of more complete AIS. Also integrated production focused MRP (Manufacturing Resource Planning) systems, that had their roots in the database developments of the late 1960s and 70s, became more important, more visible and more closely aligned with accounting functions (Jacobs and Weston 2007). These innovations combined with the PC revolution set the scene for the Internet era and more functional organisational information systems. By the late-1980s specialised accounting software packages (for mainframe, mini, and PCs) had become common for both the corporation and the accounting firm. For the corporation, software could handle the payroll, accounts payable, fixed assets, personnel and capital project analysis. For accounting firms, software packages were available for depreciation schedules, tax preparation, records management, not-for-profit organisations, work scheduling, management reports and client billings (All we provide is the best accounting software 1982: 23). On the audit side, audit software soon became available for accounting firms that had not developed their own EDP audit programmes. Combining the PC and dial-ups, accounting firms could access vast tax and accounting research service centres.

Accounting, information systems and the Internet

Introduction: nature and antecedents

The transition from the type of computerised accounting discussed in the last section and the next phase is far from clear cut. The variety of systems in use and pathways to change were diverse. Even within the more technically developed territories, individual company differences were significant both within and between different sectors and sizes of organisations. AIS as a field of practice and research has its roots in the early

days of business computer systems, and by the mid-1980s was being seen as a specific and separate, if ill defined, field (Murthy: 2016; Weber: 2016)[3]. However, from the 1990s onward there are two linked technical issues that have had a major effect on the shape, nature and power of accounting: communication technologies, particularly those of the Internet; and the increased integration and complexity of organisational information systems. Though to an extent these are separate issues, they are inherently linked, as the communication systems provide the operational capacity to integrate systems not just within a local environment but also (potentially) globally. The globalisation of business, of the profession and of information and systems technologies that provides the competitive impetus for many of the changes and developments discussed in this section, are likely to determine the 'future history' of accounting.

The Internet and World Wide Web

Though the terms are often used interchangeably, the Internet and the World Wide Web (WWW) are quite different things. The Internet is the underlying communication system and the WWW is an application that runs on top of the net in order to provide a particular human friendly interface. Though the origins of the Internet are typically traced to the US military Advanced Research Projects Agency Network (APRANET) of the 1960s and 70s, commercial uses of the net were rare until the introduction and standardisation of Electronic Data Interchange (EDI) as a means of transferring transaction data, or instigating transactions, between, typically large, organisations in the mid-1980s. By 1988 'Nearly one-third of [US] business firm[s] are either EDI users, or planning to implement EDI within two years' (Ferguson *et al.* 1990: 91; Slesinger, 1992) and use of EDI and the Internet increased internationally into the 1990s. In many cases the use of EDI was driven by the need to streamline processes in order to meet the needs of the 'just-in-time' or lean process of production and distribution (Fedorowicz 2002), and of the more global economy this entailed: both of which the Internet made possible.

The growth of the Internet was also fuelled, after 1991, by the establishment of the WWW, which, invented by Tim Berners-Lee, added a Hypertext interface to the Internet that used HTLM[4] to define and display information and URL[5]s to provide the links of the web. Used initially to provide information, the Dot-Com boom, or bubble, of the late-1990s turned the WWW into a major element of the commercial landscape, providing the universal platform for what was to become known as Business-2-Customer E-Commerce.

Both the use of EDI and the transaction interfaces of the WWW had significant effects on business transaction records and the way they were maintained, and therefore on accounting. Both of these changes mean that transaction data was input, not by employees of the company, but by outsiders: in the case of EDI, by people or systems in counterparty organisations; in the case of the WWW, by customers. The result of these

[3] The American Accounting Association launching its *Journal of Information Systems* in 1986.

[4] Hypertext Mark-up Language, a coding that defines how text and other information is defined and to be displayed.

[5] Uniform Resource Locator, in effect the internet address of a resource.

developments was the further divorce of accounting from bookkeeping and the processes of record maintenance, and shifts in the locus of control.

In addition to the processing changes it was during this period that technological change reached beyond the traditional transaction processing, auditing and report production processes of accounting, to the ways in which accounting information was communicated to external users of accounting data. Around the turn of the millennium eXtensible Business Reporting Language (XBRL) was introduced as a new standardised and regulated way of providing computer readable financial statement data across the WWW. XBRL, has since become an optional or required form of account filing standards in at least 10 major jurisdictions. XBRL does not change the fundamental financial data, but is a faster and more reliable form of electronic communication of regulated data. In addition to standard XBRL, the XBRL consortium has also introduced XBRL General Ledger (XBRL/GL) which is a definition for a standardised WWW based transactional reporting system to provide data at least at the level of general ledger transactions that can be used in more detailed accounting.[6] There are additional iXBRL (inline XBRL) standards and requirements, for example for tax reporting purposes in the UK.

There is little published historical work on XBRL, but there is potential interest in the historical analysis of why and how it came about, and how the consortium is run and maintained.

Information systems and integration: enterprise systems

Unlike the very public and well known (if not well understood) developments in communications, especially the Internet and the WWW, the process of integration of organisational information systems, including AIS and enterprise information systems has achieved much less attention. In many respects this is as true within many accounting arenas as in the wider social conscious and understanding, particularly within the accounting academy.[7] The lack of popular appreciation of this is largely understandable as the processing of transactions is not of inherent interest, even though the 'public' are increasingly an integral part of the transaction processing systems, for example though their unwitting role as primary 'bookkeeping clerks' in their Web-buying activities. It is arguably the rise of 'information systems' and the integration that this has entailed, that has had the most significant impact on accounting, albeit exacerbated by the opportunities offered by the widening and globalisation of communication technologies.

The increasing integration of earlier accounting and business related transaction and information systems continued and accelerated throughout this period, in particular the development and widespread implementation of Enterprise Resource Planning (ERP) systems. ERP are enterprise wide integrated transaction processing and decision information systems that have at their core the transaction and accounting systems of an organisation, including complex costing and management accounting functions, and had evolved from earlier MRP systems (Jacobs and Weston 2007). From an accounting perspective ERPs were, and still are, one of the most significant system developments of any time as they envelop almost the entire accounting process. Further, their foundation

[6] See https: //www.xbrl.org/ and https: //www.xbrl.org/the-standard/what/global-ledger/.

[7] See for example the discussion on technology in Boritz and Stoner (2014).

within database technologies allow, and business demands require, the implementation of rich data models that could not realistically be handled with the conventional double entry model of accounting or AISs. The result is systems that have widespread effects on the work of accountants, particularly management accountants (Grabski *et al*. 2009; Grabski *et al*. 2011). The history of the development of ERP systems, along with other Enterprise Systems such as Customer Relationship Management (CRM), Supply Chain Management (SCM) and Business Intelligence (BI) systems are outlined in Romero and Vernadat (2016), and the impact of such systems on accountants and accounting are discussed in, for example, Ballantine and Galliers (2018) and Appelbaum *et al*. (2017).

Implications for accounting and accountants

The changing role of accountants in industry

The role and work of accountants and others involved with accounting systems over time has changed substantially. The separation of record keeping from accounting continued, and more of the bookkeeping, that was once considered part of the esoteric knowledge of accounting that helped to create and preserve the professional status of accountants (Edwards *et al.* 2007), became routine, and a lot more was automated as systems became more integrated. With fully integrated AISs there was, for example, no more posting of sub-system (or day book) balances to the general ledger. In the more advanced systems many aspects of costing and allocation or apportionment (such as depreciation charges) were also automated, moving the intellectual and skilled work of accounting even more towards the preparation of financial reports, and even aspects of this were being more fully automated. However, in some other respects the role of accounting was increasing, at least in some organisations, as accounting and transaction data was becoming more in demand for a variety of types of decision support systems. In some contexts this was a 'two edged sword' as, although more data was required, accountants had to understand more complex data models and the underlying technology to be able to retrieve it. In addition, just as accountants gained independence from IT departments through the use of spreadsheets, other users were potentially able to bypass accounting expertise and information gate keepers.

The new technologies, especially advances during the third period (c.1970-2000), were potentially leading to further re- and de- skilling of the accounting and recordkeeping work force, with further female genderisation of the lower ranks of accounting work Roslender (1996). In addition to this deskilling, or redefining of the boundaries of what counted as the professional accountants' work, a new threat to status was getting stronger: the threat from computer or information systems professionals. In this context the institutional and professional histories of the different disciplines become important and there is a need to look beyond functional analysis of the power and importance of the different roles (Murray and Knights 1990). Though this issue was primarily a concern for accountants in business, accountants in practice were also under some potential threat from computer audit specialists.

The effects of IT and systems changes in the most recent period have witnessed a continuation of the issues that arose earlier, but have intensified due to the increased pace of technological change and heightened global competition, resulting from better communications and leading to greater pressure on managerial efficiency and on processing. There is also recent evidence that the long separated roles of financial and management accounting are converging under the influence of systems that are more

attuned to forward looking (including fair values) alongside the adoption of more strategic (less control) focused management accounting (Taipaleenmäki and Ikäheimo 2013).

Technology in practice and audit

With growing reliance on computers for accounting information, companies and accounting firms were faced with the problem of incompatibility with the traditional audit function. Concerns arose in the initial period of computerisation, for example Touche Ross reported in 1956 that with clients installing computers the way an audit was conducted would have to 'radically' change (Collard 1983: 123). The earlier mechanical accounting changes had much less effect, as there were still hard documents that could be inspected. As transactions were increasingly entered directly into the computer system visual inspections became impossible. The important audit issue became how to audit a computer-based accounting system. Some advocates favoured auditing 'through the computer' while others favoured auditing 'around the computer' (Monteverde 1966: 92–7). There was, however, consensus that major changes had to occur in the audit process itself. With this in mind, accounting firms, accounting educators and companies devoted significant resources to developing new programmes, concepts, and methods for auditing a computer-based accounting system.

The new audit systems involved employing staff within audit with appropriate computer expertise (Davis *et al*. 1983: 305–6), requiring the recruitment of suitably skilled individuals and/or providing existing accounting staff with appropriate computer training. Further, for each audit there needed to be a recognition of the various systems in use and an appreciation of the differences and effects of computers on audit risk and a more nuanced appreciation of management's attitudes toward controls in order for them to 'obtain a sufficient understanding of a client's internal control system' (Konrath 1999: 208, 236, 332–40). It was also important for an audit firm 'to make the machines work for you' (Monteverde 1966: 95–7), that is, to use the computer's speed and efficiency in the audit process itself. Audit tests that were impossible through manual or mechanical means could be performed in minutes or seconds with the computer.

Although the computer created the necessity to change audit practice it achieved widespread acceptance at major accounting firms, largely by speeding up the audit process (Allen and McDermott 1993: 124) and by using tax packages to divert effort away from computation and towards to tax planning.

Increased use of computers within the economy, and within accounting practice, also provided accounting firms with the opportunity to develop a new source of revenue. By 1970, all major accounting firms had established management consultancy departments, and these departments' growth and profit margins, over the decades which followed, facilitated continued rapid expansion given that a monopoly of large audit clients had already been achieved. For instance, at Price, Waterhouse & Co. in the UK, the Management Consultancy Services department's billings expanded at the rate of 15 to 20 per cent per year 'throughout the mid-to-late seventies' (Jones 1995: 295). The emergence of management consultancy departments also had a major effect on hiring practices and education requirements. Traditionally, in the USA, for example, firms hired accounting majors and expected them to become CPAs. However, in the management consultancy area, where a key requirement was that personnel possessed a strong computer background, firms began to hire non-accountants and in many firms

management consultancy departments became dominated by non-CPAs (Allen and McDermott 1993: 132–3).

Continuous audit has become a major area for research in the audit field, though this has a long history of use in some cases, for example AT&T Bell Laboratories use goes back to the late-1980s (see for example Aquino *et al*. 2008; Alles *et al*. 2018). Similarly business intelligence and data analytics, including big data, have recently become more prominent in audit research and professional consciousness and it appears that many audits now use these tools (Alles 2015; Cao *et al*. 2015).

Accounting education

The effect of changing technologies on accountants has been significant. As early as 1957 Hammond was urging that:

> The accounting faculty, as a faculty, should combine an excellent understanding of business, sound logical training, and knowledge of business data. On this base the accounting faculty should undertake the leadership in E.D.P.M. [Electronic Document Processing and Management] systems as such in schools of business administration.
>
> (Hammond 1957: 579)

By the 1970s it was becoming clear that accounting educators should respond to rapid developments in processing information and provide courses on information systems and EDP. Yet, by 1972, in only 14% of business schools accredited by the American Association of Collegiate Schools of Business (AACSB) were accounting majors required to study Accounting Systems (AS) and only 5% required students to take both AS and EDP (Schroeder 1972). In the UK, from the inception of the Batchelor of Accountancy (BAcc) degree at the University of Glasgow in 1968, computing courses were part of the curriculum (Stoner *et al*. 2018). The inclusion of computers, information systems or AIS in the curriculum of accounting programmes is not, however, universal, and its absence is currently moving towards crisis-point in at least some jurisdictions (Boritz and Stoner 2014).

Review and reflections

Hassan (2018: 24) ends his discussion in 'Taking IS research seriously' as follows:

> we have not yet missed the opportunity to build our historical tradition, but that opportunity needs to be grasped with an understanding and approach that take[s] full advantage of insights from one of humanity's oldest disciplines – history.

To a considerable extent this statement is also true in relating to the history of mechanisation, computerisation and the development of information systems in accounting and their impact.

The remainder of this section focuses separately on a number of different themes.

Defining the field

In many respects within this chapter a relatively narrow boundary has necessarily been drawn: one that looks to the processes of record keeping within organisations, the work of bookkeeping and accounting, the audit environment and, to a limited extent, accounting as a profession. Having taken this fairly constrained perspective it is, however, not entirely clear where accounting stops and information systems, of various

flavours, start. This is a criticism of the two most closely related fields: see, for example, Hassan (2018) and Markus (2011) on Management Information Systems and Weber (2016) and Murthy (2016) in relation to AIS.

However, there is positive potential in both of these critical perspectives, in that they make suggestions for improvement, largely based on clarity of approach and methods, and in Hassan (2018) the call for well-theorised historical approaches. This message is also relevant in the area of research covered here, where much is at best lightly theorised. There is clearly space in the literature for research that looks to the systems of accounting and recording in relation to broader notions and systems of accounting and/or accountability.

These issues notwithstanding, there is relatively little within this field that has been explicitly written as history of systems in accounting. An observation supported by Spraakman and Quinn's (2018) analysis of over 440 accounting history papers from the three principal accounting history journals, which does not identify any themes related to systems or technologies of accounting,[8] and identifies only one paper concerned with AIS – though even that paper (Badua and Watkins 2011) is referenced only in relation to methodology. Similarly, Matthews (2017), which covers a much broader database, does not identify any aspect of the history of the technologies of accounting systems as significant.

Much of what is reported here is a reinterpretation of near contemporary research, reports or other documentation. On the positive side it is clear that there is a wealth of such research, much of it case based, on how systems in an accounting context work or are changed or redesigned. Though this research is not in itself historical it could, with care and caution, provide a basis for detailed investigation of the phenomena with which they are concerned. They could provide data for research either at a period of time in a wider context or, by using a series of case type studies, over periods of time. In part that is the approach taken in this chapter.

Technology in accounting

As in many fields early technological change in bookkeeping and recording technology tended to be relatively simple: e.g. the replacement of simple processes with a specific tool (e.g. the calculator). As time progresses the changes tend to become more complex, with technologies replacing multiple processes, tools or steps: as does a ledger machine. Later, technologies progress towards automating ranges of activities in organised ways, for example the accounting within an integrated ledger system. Along the way further complexity is added by facilitating customisation and multiple variations, for example as ERP installations were designed to meet multiple information needs.

In the case of the accounting and recording systems discussed in this chapter we see changes being typically motivated by a combination of increasing demands for information, required in increasingly competitive and more global environments, and reductions in the costs of processing. These savings frequently being achieved via the reduction of labour costs: either via time saving or labour substitution.

Mauldin and Ruchala (1999) discuss enterprise systems, such as ERP as a complex combination of technological, organizational and cognitive factors in relation to task

[8] And given that the authors have an interests in systems in accounting, they might have been expected to identify such themes if there was relevant literature.

characteristics, and propose a meta-theory and model to help understand and research systems in their organisational settings.

The changing nature of accounting

Rosati and Paulsson (2018: 13) highlight how technological changes are implicated in the growth of complexity of IS and, following the analysis of Reneau and Grabski (1987), how the operation of accounting based systems effect most decision makers in an organisation.

The changes in technology identified have been seen to have effects on the nature of accounting work and the characteristics of those who undertake the work. For example, we see different, often lower level (or less valued), skills being required to complete the process orientated work of bookkeeping and record management. In parallel we see accounting associated more with the less routine, and invariably more valued, work. Within this situation there appears to be significant evidence, at least in the earlier years of mechanisation and computers, that the less valued roles are more likely to be associated with female labour, which at the time was significantly cheaper. This genderisation of the bookkeeping and record management processes may also be seen in the accounting field, for example it is a possible cause of the widespread gender gap in the accounting profession (as in many other fields of work).

Alongside these changes we see technology being associated with more widespread aspects of the nature of what is seen as accounting. For example the rise in consultancy within accounting practices, the shared systems responsibilities for and within ERP systems, and in the boundaries of what audit work is considered to be accounting, or at least within the domain of accountants.

Educational requirements

The discussions above show the changing nature of accounting, and above all the increasing interconnectivity and growing immediacy of the work of accountants, and of the nature of the tasks and understandings required within the field. This chapter has only lightly touched on this. However, communication between systems and technical professionals and accountants is clearly an important aspect in the efficient operation and redesign of business information processes, as is critical interpretation and analysis.

It is unclear from the extant historical research to what extent accountants' abilities in these spheres have helped or hindered the role of accountants or the progress of technological change. Research in the accounting education sphere identifies this as an area of know difficulty (see for example Boritz and Stoner 2014). This potential educational deficiency, and the role of the professions in engendering appropriate development of these competencies, raises important research questions that might well be illuminated through historical research.

Looking to the past to understand the future

The acceleration of change in technologies that is evident from the historical record, together with technology predictions, indicates that the pace and extent of change is with us to stay. Good historical research has the potential to help us better understand the past in order to cope with predicted future changes.

In this context there are many potential research topics in this field. The examples below are just a few of those that seem most promising, and for many of these it would

be potentially interesting from a socio-economic perspective to consider the role of the 'accounting profession' either in the form of the professional accounting bodies or the major accounting firms in fostering or hindering specific systems developments or implementations.

- The penetration and success of artificial intelligent systems (in accounting and decision making) within business, practice or public sectors, including ethical, social, labour and economic implications.
- Machine learning in the selection of (accounting) information used to inform decisions and determine actions.
- Continuous audit and the effects of whole population audits (rather than sample audit methodologies) on audit process, judgments and perceived risks and fees.
- The degree of implementation of ERP systems in, particularly small, organisations that might have little inherent economic incentives for doing so.
- XBRL and XBRL/SL, establishment, development and regulation.
- The international diffusion of accounting and audit technologies, and reasons for adoption/success in differing environments.
- Opportunities for accountants to be instrumental in the greater provision of detailed and near real-time information in a variety of environments that are not already well served.
- Cybersecurity of accounting, and other, data and the accountants' and auditors' responsibilities.
- Behavioural effects of (new) more onerous data protection legislation.

There are many gaps in our historical understanding in this field of study and there are many areas that have been researched where more interpretative or more critical research could further illuminate work that has already been published, much of which is predominantly descriptive rather than theoretically informed.

Key works

Appelbaum *et al*. (2017) covers many aspects of the emerging technologies in the IS field and the implications they have for accounting and accountants, including continuous audit and assurance.

Boritz and Stoner (2014) outline educational, training and competency issues that have implications for the interpretation of historical research on accountants' understanding of or reaction to systems change.

Campbell-Kelly (1992) is an interesting account of how a large British insurance company reacted to and finally accepted mechanical accounting.

Cortada (1993) examines all the major contributors (e.g. tabulators, calculators) to the mechanisation of accounting.

Hassan (2018) takes a critical look at the history of Information Systems and IS research, discusses the historiography of the field and provides detail of several studies in the area.

Hirschheim and Klein (2011) provides a detailed history of IS from the perspectives of education and research as well as the technologies and applications.

Weber (2016), Murthy (2016) and Moffitt *et al*. (2016) in the 30th anniversary edition of the American Accounting Association *Journal of Information Systems* provide a an interesting and in parts critical discussion of the history of research in AIS and associated areas.

Wootton and Kemmerer (2007) examines the development and acceptance of business machines in the USA.

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