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281

Computerisation in the Scottish Clearing Banks.

A study of Information Systems for Retail Banking in the Scottish Clearing Banks with particular reference to the Clearing and Accounting Systems.

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THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
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TECHNOLOGICAL ECONOMICS RESEARCH UNIT

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TO THE TWINS

WHO CAUSED IT ALL

FOREWORD AND ACKNOWLEDGEMENTS.

The purpose of any doctoral thesis is to describe the research capabilities of the researcher. This thesis has the additional purpose of providing the Scottish Clearing Banks with an independent assessment of their computerisation programmes over the last ten years. The project was made possible with the permission to work within the Banks granted to me by their chief executives, namely Mr J B Burke of the Royal Bank of Scotland Limited, Mr D B Patullo of the Bank of Scotland, and Mr A R Macmillan of the Clydesdale Bank Limited. Within each Bank I have worked under the auspices of divisional managers, Mr W R McKim, Mr J F Wilson, and Mr J R Heugh respectively, whom I must thank for affording me the greatest assistance. In addition, Mr Neil Honeyman of the Royal Bank, Mr J R Turner of the Bank of Scotland, and Mr A M Dunn of the Clydesdale Bank acted admirably as general advisers and liaison with many staff who gave of their time for my research. To all these I owe my thanks. Outwith the Banks thanks are also due to Mr W B Reynolds of Burroughs and Mr A S Johnston of Midland Bank who very kindly demonstrated their Image Processing experiment to me. Throughout my research I have been advised and encouraged by my two supervisors at Stirling University, Mr M Makower and Mr R Hamilton. Personal thanks go to Mr D C Mason for frequent comment and criticism, and the whole project would have been impossible without the co-operation of my husband Harry. Finally, very special thanks must go to Mrs Valerie McEwan, who, on her Wang Word Processor, typed the complete thesis, demonstrating not only considerable ability, but incredible patience in carrying out my alterations.

Catherine P Smith. August 1981.

CONTENTS

APPENDICES

ABSTRACT : COMPUTERISATION IN THE SCOTTISH CLEARING BANKS.

This thesis has three aims :-

1. To consider the value of computers to the operational objectives of the Scottish Clearing Banks.
2. To examine retrospectively the development and economics of computerisation in the Scottish Clearing Banks.
3. To examine the continued suitability of the present mode of computerisation in the Scottish Clearing Banks.

To fulfil these aims the thesis falls into three parts. The first part contains a general introduction to the Scottish Clearing Banks, concluding that there is a requirement for Information Systems. In the second part analysis of the source of Bank profits demonstrates a need for cost containment. The volumes of work involved confirm a computerisation solution as being appropriate. The current mode of computerisation and some of its consequences are examined and a retrospective look is taken at the economic impact of the decision to computerise. Finally some shortcomings and deficiencies in current approaches are identified, and one proposal made for a future course of computerisation.

The thesis concludes that :-

1. Computers can satisfy the information needs of the Banks on a cost-effective basis.
2. The decision to computerise in the mid-sixties has proved cost-effective, and has in addition had indirect consequences on the services and structure of the Banks.
3. The approach to computerisation taken in the past is no longer optimal. Current technology offers alternative information systems, more suited to likely future requirements, using comparable staff numbers.

CATHERINE P SMITH. MARCH 1982

Chapter 1 Computerisation in the Scottish Clearing Banks

1.1 Aims of the Thesis

The three Scottish Banks are the Bank of Scotland, the Royal Bank of Scotland, and the Clydesdale Bank, the first two being based in Edinburgh and the last in Glasgow. Traditionally distinct from the London Clearing Banks they still operate their own clearing system within Scotland, and issue their own Bank notes. Although the systems of banking in Scotland and England have become more alike during the twentieth century, the Scottish Clearing Banks still form a complete subsystem, particularly in terms of Clearing. The aims of this thesis are:-

1. To identify the operational needs of the Scottish Clearing Banks, and, by determining the capabilities of equipment, to assess what contribution computerisation can make towards satisfying these needs.
2. To examine the mode of their computerisation in the past, and assess the impact of the decision to computerise, both directly in economic terms, and indirectly in expanded services and structural change.
3. To examine the continued suitability of their present mode of computerisation.

1.2 Methodology

This thesis has developed in three ways:

* by identifying and examining appropriate papers and journals.
* by working in each of the three Banks collecting data and interviewing selected staff.
* by in-depth discussion with experts both within and outwith the banking field.

In the nature of things, much of the data collected is qualitative. However, there is also a large amount of quantitative data that has been produced by or found in the Banks, and, to a much lesser extent, other sources. It has therefore been possible to use mathematical and statistical techniques in many parts of the thesis. It is recognised, however, that in any question of management or economics such methods are a means to an end and not an end in themselves.

In global questions an Operational Research methodology has been applied. This can be summarised as follows:-

1. identify the objectives of the Banks
2. specify the objectives in terms of criteria
3. examine the alternatives
4. identify their consequences
5. compare the consequences of the alternatives with the criteria
6. thus identify a possible course of action.

In discussion with members of staff, answers have been found in all Banks to fundamental questions. However, because of differences in practice, not all Banks have been able to provide all the data requested from them. Thus inferences have had to be made about the general applicability of certain data. In addition, in some cases, although the researcher has had access to data, the Banks have been unwilling to have it published because of its value to competitors.

When considering particular systems problems, the methodology of Systems Analysis has been used. This is essentially an iterative process, but can be summarised as having four stages:-

1. express what is required in terms of aims, criteria, existing input and desired output
2. in discussion with current staff identify what currently happens, why, and within what time and other constraints
3. identify a logic sequence which produces the desired output within the constraints
4. specify a system to carry out the logic process.

The thesis is not concerned with the hardware or software constraints in any one bank, but considers a number of common problems, and whether systems solutions are practical. Investment appraisal techniques are used.

The research is interdisciplinary, ranging from general economics to detailed computer science. This naturally produces a work which is different in form from research in a single discipline. In single discipline research fine detail is always highly important. In interdisciplinary research the aim is to move across discipline boundaries and produce common understanding, although the researcher must be aware of the significance within each area of fine detail, and hence of its possible external effects. Therefore idiosyncracies which are irrelevant beyond discipline boundaries are not stated. On the whole computers are treated as black boxes that carry out processes. Similarly, unless relevant, the deeper intricacies of accounting systems are ignored.

1.3 The Plan of the Thesis

The aims of this thesis as stated above are not independent. In particular, aims 1 and 2 are intimately connected, and aim 3 is consequent on them. The plan of this thesis is based on an elaboration of the three aims. The aims can each be broken into components:

(1) To identify the operational needs of the Scottish Clearing Banks

In identifying the operational needs of the Scottish Clearing Banks, it is assumed first of all that they are profit-making organisations. Also a number of supplementary questions have been asked:

* Where did the Scottish Banks originate?
* What is it they offer to their customers in order to earn profits?
* Over the years has what they offer basically changed or remained the same? In other words, has their actual business changed?
* In order to operate their business, apart from deposits, what do they need?

(2) By determining the capabilities of equipment, to assess what contribution computerisation can make towards these needs.

Examination of the business of the Banks identifies a need for data processing, and information production and dispersal. Modern technology has therefore been assessed in the light of the following questions:-

* What is required to produce Information?
* What are the components of an Information System?
* What technology is available for each component?
* What advantages might computers have in information production over clerical systems and also manual systems?

It has therefore been necessary firstly to develop a structure for an Information System, and secondly to look at the history of available technology, and also to extract appropriate developments from current technology.

(3) To identify the mode of their computerisation in the past.

For this it has been necessary to do a comparative study of

a) general hardware installation development
b) technology as used in the Banks
c) the mode of operation of manual and machine systems
d) a detailed comparative study of the accounting and clearing systems in the three Banks.

Item (a) is intimately connected with the question of the history of the Banks (in 1.3(1)) and the structure of the Banks (in 1.3(4)). Item (b) is intimately connected with the development of technology (in 1.3(2)) and the services of the Banks (in 1.3(1)). Item (c) is intimately connected with changes in work volumes (see 1.3(1)) and available technology (1.3(2)). Item (d) is intimately connected with changes in management structure (1.3(4)) and available technology (1.3(2)).

(4) To assess the impact of the decision to computerise both directly in economic terms, and indirectly in expanded services and structural change.

The component questions above in (1) to (3) are all necessary in assessing the impact of computerisation. In addition it has been necessary to question whether other factors have masked the results of computerisation. Thus, the background to banking in Scotland has been examined. Against this background it has been asked whether computerisation can be identified as the cause of changes:

* in general structure]
] the indirect impact
* in actual work done by the Banks]

* in profitability - the economic impact.

It is virtually impossible to assess direct economic effects of computerisation, because of the many factors influencing costs in banking, and because of the changes in actual work done. Thus, global observations on the Banks have been used, and assumptions drawn from these about what might have been the situation if computerisation had not been carried out, or had been delayed.

- 6 -

As a result of the interweaving of all these questions the thesis has been structured in the following order:

Chapter 2 a background to the Scottish Banks.

Chapter 3 a study of the cost aspects of information in Banking, and of work growth in the Scottish Banks.

Chapter 4 a study of technology, particularly its relevance to information production, along with a study of the communication networks of the Banks.

Chapter 5 a detailed study of accounting and clearing systems in the Scottish Banks.

In Chapter 6, the possible cost savings that might be attributed to computerisation are estimated, drawing on observations made throughout Chapters 2 to 5.

In Chapter 7, emphasis changes onto Aim 3 : To examine the continued suitability of the present mode of computerisation. In order to do this it has been necessary to approach the subject from a different angle.

For Aims 1 and 2 the approach was to use the status quo as a yardstick (both in cost and operating efficiency) and measure whether the computerisation was an overall improvement. For this third aim the question is whether, measured against an ideal, the current approach is, overall, the most attractive. Thus, it has been necessary to develop such an ideal, and this is set out early in the work (in Chapter 3). There, having assessed the chief operational need of the Banks to be information production in an accurate, timely and cost effective manner, the requirements for a COMPLETE INFORMATION SYSTEM with EFFICIENT DATA RETRIEVAL are set out. The present mode of computerisation is, in Chapters 7 and 8, measured against this ideal.

Shortcomings of the present system are therefore investigated. In addition, in Chapter 9, current technology is again searched for an alternative system which approaches the ideal more closely. Since costs for future systems are unknown, because of the research and development nature of the environment, comparison of economic feasibility can only be made on the basis, not of set-up costs, but of the possible resultant savings in running costs.

The current value of such a system in comparison with the current mode must also take into account non-economic factors such as the degree of approach to the ideal, including adaptability to future conditions.

The thesis is summarised in the Resume in Chapter 10.

As a result of the two approaches in the thesis, the recommendations, which form part of the conclusions, themselves fall into two parts - the first referring to the setting up of a system, approaching the ideal of Chapter 3, and the second suggesting improvements in the current systems. The research, of necessity, leaves a large number of questions unanswered, and in the last section reference is made to some of these.

1.4 Abbreviations used in diagrams, appendices etc.

B of S	Bank of Scotland
RBS	Royal Bank of Scotland
CB	Clydesdale Bank
B of E	Bank of England
CSCB	Committee of the Scottish Clearing Banks
BACS	Banks Automated Clearing Service
IBRO	Inter-Bank Research Organisation
CIT	Cash Issuing Terminal
TT	Teller Terminal
MICR	Magnetic Ink Character Recognition
OCR	Optical Character Recognition
DCV	Docket Control Voucher
COM	Computer Output on Microfiche

"In house" terms are defined in the Glossary.

Chapter 2 "The Scotch System of Banking"

2.1 A History of Banking in Scotland

The Bank of England and the Bank of Scotland were born in consecutive years, 1694 and 1695, and may be attributable to the same man, William Paterson, who shortly thereafter was to sow his seed even more wildly in the disastrous Darien expedition, which caused the bankruptcy of Scotland, precipitated the Union of the Parliaments in 1707, and which ultimately gave birth too to the Royal Bank of Scotland in 1727.(1) It is unfair, though, to place the blame for all history at the door of one man, as many would agree that the growth of Banking, and the unification of Great Britain were equally natural and inevitable. It is feasible, for example, that both are the outcome of the human appreciation of material wealth.

Private banks, formed by merchants and specialising in credit to merchants, thus gave way to the newer concept of Joint Stock Banking only as late as 1694. In that year, the English government, wanting to finance a war against France, found as usual that money was tight. Unfortunately, so was creditability with the rich. Several schemes were suggested, but the one adopted was that put forward by William Paterson. In return for a loan of £1,200,000, bearing interest at 8%, the subscribers, who were limited to a maximum subscription of £20,000 each, were allowed to form themselves into a joint-stock company under the title of "The Governor and Company of the Bank of England." In return for the loan, the Bank of England was granted a number of privileges including the right to issue notes payable on demand up to the maximum amount of the Bank's capital. It was given monopoly powers and its maintenance of this monopoly was to be the cause of the major difference in the banking systems of England and Scotland.

Paterson had cronies, and by the spring of 1695 other London Scots "were fired with a desire to have in Scotland a National Bank, not primarily for the support of Government, but one designed to promote the trade and industry of Scotland."(3) The Scottish Parliament, in July 1695, enacted a Bill "For the Erection of a Publick Bank", under which the Bank was to have a monopoly for twenty-one years, and all shareholders were to be deemed naturalised Scots. This bank also had the right of note issue. So began the Bank of Scotland. It was never, however, to become a Central Bank.

Individual interest in venture was high in Scotland at this time, especially with the awareness of the profits accruing to London from trade with the Americas. William Paterson had already been quick off the mark with an idea for the "Company of Scotland trading to Africa and the Indies" following an Act by the Scottish Parliament in 1694 for the "Encouraging of Forraigne Trade".[4] However, although at first some English money was promised to this scheme, London merchants were quick to realise the danger to their own monopoly profits, and lobbied the joint king, William III, who withdrew his initial support for the scheme. The Scots went ahead, raising £228,000, which was invested, and lost. But the Scots are stubborn, particularly William Paterson, and in 1698 a Scottish company, financed by subscription from all over Scotland, began operating, its destination Darien, its intention to secure profit by trade with Central America. In the event, due partly to ill-luck, partly to bad planning, and partly to harrassment by English traders, the company failed. In the negotiations for the Union of the Parliaments of England and Scotland, begun in 1702, this failure featured as a wrong requiring retribution. By the Act of Union in 1707, England agreed to pay Scotland an "Equivalent" in compensation for Darien and other losses.

Cash is not got out of the English easily, and many creditors received debentures instead. In order to ease the collection of interest from the Government, two "Societies of the Subscribed Equivalent Debt" were set up, one in each of England and Scotland. In 1724 both societies were reformed by Act of Parliament into the Equivalent Company, registered in Scotland.

Meanwhile, even before the Union, a funny thing had happened in the Bank of Scotland. Although money was said to be scarce, the Scots have always been able to pull some out from under the bed, and on March 10th, 1704, one of these canny chiels, James Hamilton of Pencaitland, applied to the Bank for leave to deposit the sum of £3,624 sterling which he happened to have lying by him, and did not feel safe leaving it at home when he went on a trip. He was given permission to deposit the money. This was followed by so many similar applications, that in 1708 the Board of Directors decided to offer it as a Bank service. Retail banking had begun.

It was profitable, and the Equivalent Company liked it. The Bank of Scotland had allowed its monopoly to lapse in 1716. The Equivalent Company applied for a charter to operate as a Bank of Issue in Scotland, and in 1727 began operating. Thus, at an early stage there was more than one large Bank in Scotland, ultimately giving rise to the peculiarly Scottish Branch system of Banking. After initial antagonism, there proved to be room in Scotland for two banks, and agreements were soon reached for the acceptance and exchange of each other's notes. The Royal Bank of Scotland, as the new bank was called, made a startling innovation the very next year. This was the Cash Credit, or overdraft, beloved of many a Scot ever since.

The Bank of England was greatly protected by law, south of the border, this protection only increasing with time, preventing the creation of other strong English banks within a wide area around London. Country banking did, however, grow, but legal limitation of the number of partners made it impossible for the system to be other than small-scale, fragmentary, and relatively unstable whereas in Scotland, the norm became the large bank. With the vastly different provisions of Scots Law, the development of banking in Scotland thus took a very different course. Small banks were formed, but in addition, a third powerful joint-stock bank, the British Linen Bank, was established in 1746. Active competition resulted. In addition, an atmosphere was established in which the setting up of branches was not only competitively attractive, but necessary.(4)

Inevitably, even the new ideas of banking embodied in the large banks and the smaller private banks became reactionary and remote from the public that had originally been served. By the early nineteenth century, despite there being branches of the Edinburgh banks in Glasgow, a gap had opened which enabled the founding of a spate of new Joint-stock banks, heralded by the Commercial Bank with a Royal Charter of Incorporation dated 1831, by which time it had already established thirty thriving branches; it was soon taking over other smaller, but successful banking ventures. The Clydesdale Bank was one of the last to reap the benefits of note issue, which was a main factor in the promoting of Branch banking.

Inevitably, not all banks were successful. On numerous occasions customers suffered considerable hardship as a result of bank failure, both in England and Scotland. One feature of bank failure was the printing of notes beyond the credit base of the issuing bank. Experience in England suggested that banking and note issue were separable. In 1833 there had been an apparent relaxation of the monopoly of the Bank of England, in allowing joint-stock banks to be established within 65 miles of London. However, at the same time, the Bank of England became the Central Bank of the Country with its notes made legal tender for the first time - in other words they were as good as gold. As the new banks successfully operated with the Bank of England notes, the outcome was the Bank Charter Act of 1844, controlling note issue, so that eventually the Bank of England alone could issue notes in England and Wales. In 1845 a Scottish Act was passed also regulating the issue of bank notes. The then nineteen banks in Scotland were limited to an authorised note issue, the Fiduciary issue, amounting to £3,087,209. Any excess over this issue had to be covered by legal tender.

This Fiduciary issue, once an important aspect of the profitability of Scottish Banks, was never expanded, and now appears effectively as a nominal advantage. However, the right of note issue is still a considerable advantage for the operation of branches, as it is possible to keep unissued notes as "till money" which is not, while in the possession of the bank, considered as circulating note issue.

In Scotland, unlike England, no individual bank was given the status of Central Bank, each Bank operating independently and without any rights of regulation as exercised by the Bank of England, and this position has continued, with the Bank of England alone acting as a Central Bank in the United Kingdom.

It was not until 1864 that the first branch of a Scottish Bank, the National Bank, was opened in London. This caused considerable annoyance and controversy because of the note issue question, but as long as National Bank notes were not passed out from a counter of its English branches, it was not deemed to break the law. The other Scottish banks soon followed, establishing strong contacts with the London money market.

In spite of precautions, collapses were not yet a thing of the past. The City of Glasgow Bank, an unlimited company, went to the wall in 1878. Massive losses reduced many shareholders to insolvency. The Manager, Secretary and six Directors were arrested on a charge of fraud, tried, and jailed. At that time there were in Scotland seven other unlimited liability banking companies who quickly took steps to register under the Companies Act of 1879, limiting the liability of shareholders. By their charters the Bank of Scotland, the Royal Bank of Scotland, and the British Linen Bank were already effectively limited liability companies. However, they, like the rest, now adopted the practice of having their accounts and balance sheets audited by independent accountants.

The late nineteenth and early twentieth century showed more changes in England than in Scotland, with the amalgamation of small country banks to form the large London Clearing Banks, with branches in the Scottish manner. One hundred years ago, Scotland with a handful of banks, and England with hundreds, seemed poles apart. In Scotland too, the emphasis was on the deposit account, while in England the bank cheque was almost universally preferred. There was, as it was known at the time, 'the Scotch system of banking'.

From about 1880 onwards, English banking was transformed by a series of amalgamations, so that by 1918 there were a mere forty separate English banks. Treasury intervention stopped the process till the 1960's, when a report on Bank Charges prepared by the National Board for Prices and Incomes criticised the lack of competition among banks. It made clear that further bank amalgamations would not only be countenanced by the Treasury, but actually welcomed. Such was the result within a very short space of time.

The Scottish banks had been undergoing mergers of their own over the years, so that in 1965 there were five, viz.

National Commercial Bank of Scotland Limited
The Royal Bank of Scotland
The Bank of Scotland
The British Linen Bank
The Clydesdale Bank.

In 1969 the Bank of Scotland and the British Linen Bank merged to form the Bank of Scotland, mainly through the interest of Barclays Bank, which owned the British Linen Bank, to enhance its Scottish investment.

In the same year the Royal Bank of Scotland and the National Commercial Bank of Scotland Limited merged to form the National and Commercial Banking Group, with two subsidiaries called the Royal Bank of Scotland, and Williams and Glyn's Bank, a member of the London Clearing House. (Here, some interest from Lloyds Bank emerges as a cause of the merger). This group changed its name in 1979 to the Royal Bank of Scotland Group Limited. The Clydesdale Bank had previously been formed from two banks wholly owned by the Midland Bank, these being the Clydesdale Bank and the North of Scotland Bank.

The three banks, the Bank of Scotland, the Royal, and the Clydesdale, dominate Scottish banking business, although in the past ten years, with the development of North Sea Oil, branches of other banks have been set up in the country. Although there are differing degrees of Scottish and English ownership of the three banks they operate as Scottish banks, in strong competition with Sassenach interlopers. The evidence given by the three banks to the Wilson Committee [9] leaves it in no doubt that these banks consider themselves still to provide 'a Scotch system of banking'.

Scotch or not, though, there is a fundamental necessity that has existed in retail banking since its inception. Throughout their history services have been provided by the Scottish Banks to customers in exchange for the use of their deposits - from the safe-custody of the first retail deposit, to the financial cash services of the present day. In order to keep track of transactions and provide bank services, and later as a major profit-earning service in its own right, the Banks have provided information to customers, in the form of accounts and evidence of transmitted money. These records and services all require the use of data and information, about financial operations, about the customer himself, and about other banks. Most bank activities require the provision of information to customers, Bank staff and others. In addition, for its completion, the particular service of money transmission requires the transfer of information between Banks. Thus, each Bank needs its own information system, and in addition, there has been necessary, for many years, an inter-bank data-transfer system, which feeds the information systems of the respective Banks. This data-transfer system consists largely of the clearings, and the information systems of the individual Banks consist largely of accounting systems.

The requirement for information systems has existed in a variety of forms since the founding of the Banks, and in any Bank the information system is itself essential for continued operation. Its form may change, but its absence would make the Bank's operation impossible.

FIG 2-1

Extract from the Written Evidence to the Wilson Committee

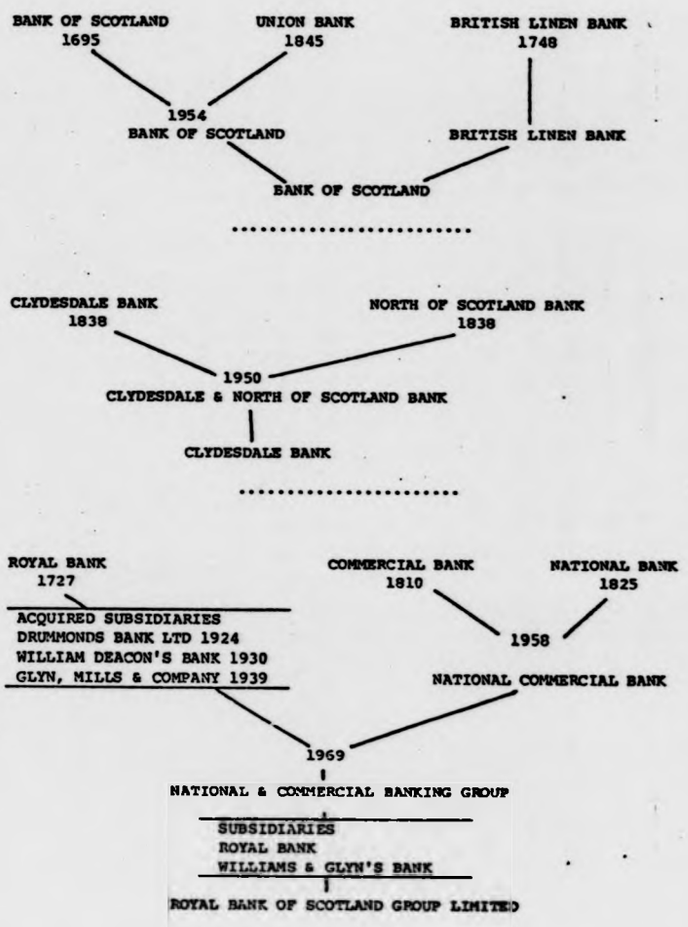
BARCLAYS BANK holds 35% of the equity of the Bank of Scotland. This stems from acquisition of 100% of the British Linen Bank in 1919.

LLOYDS BANK holds 16% of the equity of the Royal Bank of Scotland Group Ltd. This stems from 100% ownership of National Bank of Scotland in 1918, diluted to 36.6% of the equity of the National Commercial Bank of Scotland in 1959, and to 16% of the National Commercial Banking Group Ltd in 1968.

MIDLAND BANK own 100% of the equity of Clydesdale Bank. This stems from the acquisition of 100% of the equity of the Clydesdale Bank in 1919, and North of Scotland Bank in 1923.

Note: This states the equity position after the mergers of the early 1970's. There was no change by 28th February 1981, which is the end of the period examined in this thesis.

FIG 2.2 BANK MERGERS IN SCOTLAND



2.2 Recent Influences on Banking

Banking law in Britain requires Banks to maintain deposits with the Bank of England, and to keep a certain level of liquidity.

Throughout the sixties there were in addition strict limits imposed by the Bank of England on Bank lending; Special Deposits were called for by the Bank of England and were a significant weapon in curtailing lending.

The seventies started on a positive note for the clearers and the Scottish Banks, with the resolution to disclose hidden reserves and declare true profits, after allowances had been made for bad and doubtful debts.(10) Although this assisted inter-bank performance comparisons, the unknown nature of bad debt provisions meant that less information was being released than might be expected, but an incentive to competition had been established. This was enhanced in May 71 when the Bank of England published its paper "Competition and Credit Control". This document proposed the removal of the Banks' interest rate agreements and the maintenance by all banks of a minimum percentage of their sterling deposit liabilities in specified reserve assets. Ceilings on bank lendings were to be removed, but the authorities were to reserve the right to make qualitative requests.(6)

The Bank of England also considered that it might be necessary to constrain the creditor interest rates the banks could offer on retail deposits in order to limit the impact of competition on building societies and savings banks. This paper spelled the end of the system of agreements on interest rates and charges which had been a feature of the Scottish Banks for almost 150 years. That system had already been largely dismantled, and virtually all that remained of it was the agreed rate of interest on Deposit Accounts. It was felt that the major change would be that the clearing banks would no longer be singled out for special treatment which made them almost a part of the public sector of the economy, and that they would be treated equally with all other institutions in a freely-competing financial sector.(11)

In September 71 the details were published - and did not please the Scottish Banks. Institutions recognised as Banks by the Bank of England had to maintain at least 12.5% of eligible liabilities in specified reserve assets.

Scottish Banks' liquidity ratios were traditionally calculated on deposits plus notes in issue (which were covered by English notes). This usually fluctuated around 30%, causing a superficial similarity with the English Clearers. However, closer examination revealed a large discrepancy in available monies for Reserve assets.(12)

TABLE 2.1

1971 Net Deposits	London Clearers	Scottish Banks
	%	%
Cash	8.1	17.0
Money at call	15.1	12.0
Treasury Bills	2.4	0.5
Other Bills	10.1	4.4
	35.7	33.9

To help meet this point, after discussion with the Bank of England, the authorities agreed to repay in cash the Special Deposits of the Scottish Banks. In England these were in effect directly converted into Government Stock.(13) Certain additional measures were also proposed to the Scottish Banks in recognition of their distinctive nature. The Liquidity bases of the English Clearers and the Scottish Banks were thus brought roughly into line.

All the Banks were quick to create their individual base rates, abandoning all previous credit agreements. In theory the new system permitted a much wider range of lending rates than previously, and a greater degree of fluctuation in the rates applicable to special categories of loans. The Banks' interest rates were now free to move in closer relation to market rates generally.(14)

It was thought, because of the long-term build-up to the 71 paper, that this freedom from credit restriction would be more lasting than on previous occasions. It was clear that the intention of the new system was to offer the clearing banks much greater freedom to determine their own lending.(16) It was expected that bank services would improve significantly in an attempt to compete. Immediate results were indeed felt by personal current account holders, with changes in the system of bank charges.(15)

However, by late 72 calls for Special Deposits had re-appeared, taking on a new form. Interest was withheld on that part of the banks' special deposits relative to customer current account balances, in evidence of the general recognition that the bank profits were increasing due to the so-called endowment element.[13]

Moreover, the era of the credit squeeze had begun with the Government announcement of severely restrictive measures to raise interest rates to check the growth of credit. Additional special deposits were called in.

By the end of 73 a non-interest bearing supplementary special deposit requirement scheme had been invented, with the intention of containing bank lending by penalising excessive growth in interest bearing eligible liabilities. This was suspended for a time in late 75, only to be re-activated in November 76. The unexpected economic stability of 77 allowed it to lapse once again, only to be revived once more in August 78, under the nickname of the "Corset".

It was strongly felt in Banking circles that this would lead to distortion or even limitation in the allocation of funds to industry, and to the encouragement of "fringe" institutions.[13] Within a year, it was indeed causing considerable trouble for the English Clearers.[17] The difficulties in maintaining bank profits in this artificial environment was expected to promote efficiency measures such as rationalisation of the branch systems.

However, an unexpected event occurred in October 79 - the removal of all exchange restrictions.[18] This should enable the banks in the longer term to expand even more their international business, but it does throw wider open the possibilities of foreign competition.[19] In June 1980 this was followed by the abolition of the Corset,[20] leaving the banking system at the beginning of 1981 in an apparently healthy position of an unrestricted market. As always, there are ties - it was made quite clear to the banks that they were still under the priority lending guidelines, and that any attempt to market aggressive personal savings and loan packages that might threaten the building societies would be unacceptable.

In order to control, information is required. In the past figures supplied to the Bank of England on request have been used as a basis of control. The Central Bank demands regular returns from each of the Clearing Banks, and these require information to be gathered about the types of account holders and accounts, and amounts contained in accounts. Additional information requests have been made over time, and it becomes progressively more difficult to satisfy these requests within time limits without recourse to the speed of computers. In addition, because of the penalties incurred for infringing regulations, and the losses inherent in too generously avoiding infringing them, it is in the interest of the Banks to maintain reliable internal information systems.

Controls are by no means yet static. The Bank of England continues to make new requests - at 1981 requiring an analysis of the terms of advances. This is seen as yet another possible basis for control. It is to be noted that such an analysis is not easily carried out except on a computer, and in preparing their submissions the Banks are being forced to develop a suitable system for extracting the information from their computer records. However, at the same time, it must be said that the Bank of England would have been unlikely to request information only available using computers if computers had not become widespread. (This does not mean, though, that the data is there to be made use of.)

Though controls exist which are designed to channel funds, there has, for a number of years, been adverse criticism of Banks, among others, for having lost sight of their original objective of promoting the flow of money towards investment. As a result, in October 1976, a Committee was formed chaired by Sir Harold Wilson to review the functioning of financial institutions.(21) Evidence was requested by the Committee from all interested parties, including the Committee of Scottish Clearing Bankers. The Committee reported in mid 1980, giving recommendations on the Banks, the Stock market, the investing institutions and the Building Societies. It is thought that the activities of the Committee had an importance beyond the content of the report itself in provoking serious thought in the institutions about their role.(22)

In the main the conclusions of the report were negative. For example, it came out strongly against nationalisation, and against excessive interference by regulatory bodies external to the institutions.

In considering the question of funds for industry, fault for lack of finance was not found to lie with the institutions. One recommendation, however, was for the establishment of a loan guarantee scheme for small firms on an experimental basis. Banks fear that this could give encouragement to non-commercial lending.

The Report came out strongly in favour of fiscal neutrality, particularly criticising the position of the Building Societies. The Committee recommended that these societies should pay corporation tax at the full rate of 52% instead of at the reduced rate of 40%, and that composite rate arrangements should be ended. Under this arrangement the societies pay interest to depositors net of tax at the basic rate and then account for the tax at a rate which, because some of their depositors do not pay tax, is lower than the basic rate.

The result is that the societies are able to narrow the differences between their lending and borrowing rates, and that there is a cross-subsidy from non-taxpaying depositors to others. In addition, the Building Societies' cartel arrangements governing the level of interest rates were strongly criticised.

It remains to be seen how far competition between financial institutions will develop.

From the above it can be inferred that recent influences on banking have, besides creating an environment conducive to changing services, increased the already existing need for information.

(The position of the Scottish Banks in the Scottish economy has been considered elsewhere by the author.[25])

2.3 Changes within the Scottish Banks

2.3.1 The Scottish Banks are predominantly Retail Banks. Retail Banking is taken to be the collection of small deposits from customers, and the making of small (relatively speaking) advances.

The work of retail banking is carried out by:

Management
Accounting staff
Clearing staff
Staff involved in moving documents & money
e.g. Cashier dept., clearing dept. etc.
Telling and ledger staff.

Thus this includes all Branch staff of a Scottish Bank, and a large number of head office staff, including most senior management.

In 1969 the Report of the Directors of the Royal Bank of Scotland stated the following:

"Activities : the company and its principal subsidiaries are engaged in the business of Banking and allied financial services."

In 1980 the statement was as follows:

"Activities : the company and its subsidiaries are engaged principally in banking and other financial services."

The apparent similarity in these two statements belies the genuine difference between that Bank in 1969 and the Bank today. There has been a widening of the activities of the Bank during its ten years of existence, which has had a direct effect on the complexity of the accounts. Similar changes have occurred in the other two Banks. Many areas have expanded, widening services for customers. Significantly, there has been an increase in wholesale Banking. Whereas in 1969 virtually all management was involved in what can be described as retail banking, only a proportion of management is so involved today. Areas of expansion include share registration, Trustee and Investment, International, payroll, etc. All these areas involve a large amount of data processing where a computer implies considerable cost advantage.

The Tables 2.2 to 2.5 demonstrate how the retail outlets have remained more or less constant over time, whereas the proportion of non-retail management has greatly expanded. It is noteworthy how many of the departments described as non-retail have grown from nothing over the ten years.

The Royal Bank and the Bank of Scotland have created new divisions to cater for non-retail business. The Clydesdale Bank[11] has chosen a different method of diversification - by the creation of subsidiary companies - these being involved with general finance, insurance broking, and computing consultancy. These are not strictly comparable with the apparently similar divisions of the other two banks in that they are expected to compete as separate companies, rather than having appropriate business directed to them on a work-sharing basis. By the nature of the present structure and published information, it is not certain whether the management structures accurately reflect what would be the senior management involvement in a monolithic arrangement. However, the same trend away from retail banking can be seen. (It should be noted that the other two banks do computing consultancy with staff reflected in the "retail" figures, but the extent of their work is not considered by the banks themselves to be of the same order as in Scottish Computer Services Ltd. Therefore, this subsidiary of the Clydesdale Bank has been considered "non-retail" although all computing in the other two banks has been treated as serving primarily the retail function.)

In conclusion it can be said that all three banks have changed over the decade 1970 - 1980 from purely retail banks to more general financial institutions, though remaining still mainly retail.

Some of this expansion can be attributed directly to computerisation - for example share registration utilises the banks' own systems for shareholder records, and grew from marketing an already extant system with wider application than in-house use. Similarly, company payroll schemes are also a logical extension of an in-house system.

Change is noticed also in purely retail banking. Retail banking in 1970 offered to customers basic deposit and current accounting facilities. At the beginning of the decade the Banks were installing off-line cash dispensing machines, and with "Competition and Credit Control" in 1971, the Banks also began to offer various loan packages to personal customers. A number of new account types and services have appeared over time - Access, and Barclaycard, offering customer credit on an extended basis; cheque guarantee cards, later extended to Eurocheque cards, allowing personal withdrawal of money from current accounts away from home branch; Bank Giro credit transfers offering an alternative to cheques; budget accounts, offering revolving credit.

The standing order system was extended, and augmented by the introduction of the direct debit and automated credit systems - both totally computer-based. Cash issuing terminals, on-line, and operated by customer magnetic stripe cards came to Scotland in the late seventies, and this has recently been extended by the Royal Bank of Scotland with the introduction of their "Cashline Account" which is an account operated with neither pass book nor cheque, but simply with the magnetic stripe card used either at customer or at teller terminals. It is expected that the other two banks will also offer card accounts to customers in the near future. These developments are also totally computer based and designed to contain the costs of active deposit accounts, and eliminate cash cheques - i.e. those cheques used by customers, particularly at their own branch, purely to withdraw cash from their own account. In addition these cards effectively extend available bank open hours.

Despite changes in appearance, the retail banking function basically remains what is has been for centuries - the collection of deposits, the making of loans and advances, the keeping of accounts, and the provision of money transmission services. Computers have not changed the basic function. Even with cash issuing terminals the computer has been seen as a cheaper alternative to counter services.

Otherwise, where possible, it has been the policy of the Banks to offer to customers computer services which represent only a marginal cost to themselves because the major outlay has already been made in writing the systems for normal Bank use. Where spare capacity exists on machines and a system is available, additional work can be carried out at relatively very low cost. Form, but not function has changed.

YEAR	69	70	71	72	73	74	75	76	77	78	79	80
General Management Retail Banking & Computing	41	40	43	44	46	47	47	37	39	43	39	44
Trustee, Investments etc.	13	13	13	13	16	15	15	7	7	7	7	7
Overseas & International	9	9	10	11	10	18	19	13	13	17	20	20
Insurance, Registrars & Economics			1	7	10	12	12	9	8	8	7	7
Personal & Business Finance Services				5	9	9	12	5	5	6	6	6
Marketing & P.R.									4	6	6	7
Non-Retail Total	22	22	24	36	45	54	58	34	37	44	46	46
Total	63	62	67	80	91	101	105	71	76	87	85	90
Non-Retail Proportion %	35%	35%	36%	45%	49%	53%	55%	48%	49%	51%	54%	51%

TABLE 2.2

NUMBER OF NAMED OFFICIALS IN ANNUAL REPORT & ACCOUNTS 1970 - 1980 ROYAL BANK OF SCOTLAND

YEAR	71	72	73	74	75	76	77	78	79	80
General Management Retail Banking & Computing	35	34	36	36	50	53	57	50	50	56
Trustee, Investments etc.	3	3	3	3	3	3	3	6	8	7
Overseas & International	1	1	1	2	2	6	17	24	21	23
Insurance, Registrars & Economics	2	2	3	4	4	4	4	4	5	4
Personal & Business Finance Services			1	2	4	2	2	2	2	3
Marketing & P.R.	2	2	2	4	4	3	4	3	3	2
Oil			3	5	6	6	6	2	2	2
Non-Retail Total	8	8	13	20	23	24	36	41	41	41
Total	43	42	49	56	73	77	94	91	91	97
Non-Retail Proportion %	19%	19%	26%	36%	32%	31%	38%	45%	45%	42%

TABLE 2.3

NUMBER OF NAMED OFFICIALS IN ANNUAL REPORT & ACCOUNTS 1970 - 1980 BANK OF SCOTLAND

YEAR	69	70	71	72	73	74	75	76	77	78	79	80
General Management Retail Banking & Computing	39 (2)	39 (2)	40 (3)	44 (3)	58 (5)	62 (4)	68 (7)	71 (7)	77 (7)	64 (7)	65 (8)	
Trustee, Investments etc.	7	7	8	5	12	13	15	14	16	14	16	
Overseas & International (C.B. INTERNATIONAL FROM 78)	7	7	7	6	8	9	9	10	10	13	17	
C.B. Finance Corporation Ltd	3	3	2	2	2	2	1	2	2	2	2	
C.B. Insurance Services Ltd		2	2	2	2	2	1	1	1	1	1	
Scottish Computer Services Ltd			3	3	3	3	2	2	2	2	2	
Marketing & P.R.				1	4	4	3	3	3	3	3	
Management Development Adviser & Planning					2	2	4	5	4	4	4	
Non Retail Total	17	19	22	19	33	35	35	37	38	39	45	
Total	56	58	62	63	91	97	103	108	115	103	110	
Non-Retail Proportion %	30%	33%	35%	30%	36%	36%	34%	34%	33%	39%	41%	

TABLE 2.4
NUMBER OF NAMED OFFICIALS IN ANNUAL REPORT & ACCOUNTS 1970 - 1980 CLYDESDALE BANK

2.3.2 The growing importance of computers in bank operations is reflected in the development of Systems Divisions in the Banks.

The Bank of Scotland was the first Bank in the U.K. to use computers when it installed in 1959, IBM 420/421 series tabulators equipped with a special device to enable them to calculate interest. By 1970 the Bank had two IBM 360/30 machines, and had begun its Branch Terminal Network. At that time there was no Systems Division in the Bank, although there was a General Manager, Computer Services. By 1971 a separate company, Bank of Scotland Computer Services Ltd, had been set up as a wholly owned subsidiary of the Bank. 1975 saw this company reabsorbed into the Bank as a fully fledged division, under a Divisional General Manager. During 1976, the growth of the area resulted in the appointment of an Assistant General Manager (Computer Services). On the retirement of the Divisional General Manager no direct replacement was made, although Computer Services is recognised as a large important division in its own right. It falls within the responsibility of a Joint General Manager of the Bank who (at 1980) is also responsible for virtually all the departments relating to retail banking, including Computer Services, Management Services, Personal Financial Services, Development, Marketing and Public Affairs Department. Within Systems Division itself development work is carried out by five project teams, directed by management. One team is involved in developing and maintaining packages used by bank customers. Another is concerned with the work of the subsidiary company North West Securities, while the remainder are involved in developing retail and wholesale Bank systems, such as teleprocessing and international payment systems. There is in addition a large number of staff for computer operations.

In the Royal Bank of Scotland, both Banks constituting the merger at 1969 had computerisation programmes on hand, and to a large extent had computerised current accounts, deposit accounts, staff salaries, traveller's cheques, home improvement loans, and other smaller aspects. The merger and decimalisation, brought a keen wish to bring all branches onto an on-line system. At that time, Electronic Data Processing was recognised as a division of the Bank, under an Assistant General Manager.

Development of the importance of computerisation - with the completion of branch networks, and extension to international connections via SWIFT - merited the promotion of the Assistant General Manager to General Manager (Electronic Data Processing) by 1977. The following year an additional Assistant General Manager was appointed, and 1980 saw yet more recognition of the expansion of the computing division with the appointment of a second Assistant General Manager. Within the Royal, like the Bank of Scotland, the greater part of computer manpower is directed to retail banking.

The Clydesdale Bank was not involved in the mergers of the late sixties, and the development of the Computer Division has therefore grown more smoothly from the pre-computer era to the present highly technical age.

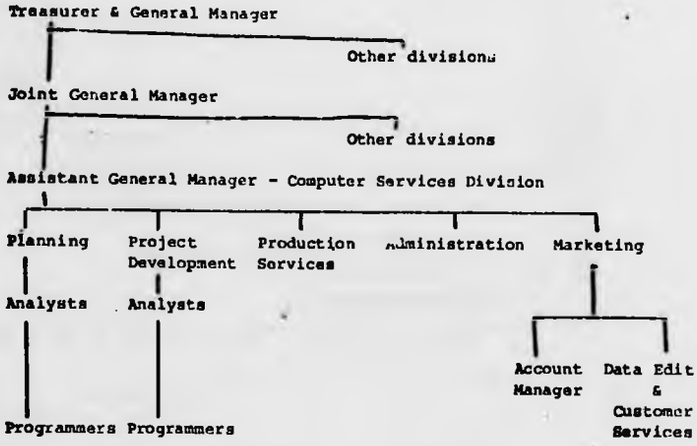
In 1965 the first computerisation in the Clydesdale came under the authority of Organisation & Methods department. The importance of the computer had grown by 1971 to such an extent that the Manager (O&M Department) was promoted and redesignated as General Manager's Assistant (Automation & Research). Two managers were also appointed, one for the Computer Centre, and one for development. In the same year, Scottish Computer Services Ltd was set up, and this has continued since as a separate entity providing general computer services to a variety of customers. It is a wholly-owned subsidiary of the Clydesdale Bank. 1973 saw a further rationalisation of the growing computer division, with a split in responsibility between the two Assistant Managers - for Automation & Research, and Computer Operations. 1975 saw the General Manager's Assistant promoted to Assistant General Manager. Shortly thereafter another General Manager's Assistant (A & R) was appointed. The present structure of the division reflects the double-barrelled name, with emphasis placed separately on Research, and computer development and management. Again, effort is predominantly directed to retail banking.

FIGS 2.3 and 2.4 indicate the current structure of the Systems Divisions of the three Banks, and their hardware histories. Fig 2.4 suggests a considerable increase in commitment to computerisation over time.

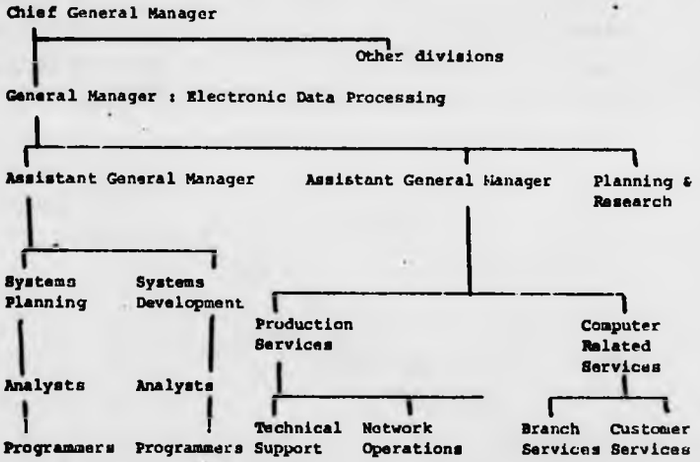
In conclusion it can be said that although the fundamental functions of the Banks have not changed over time, the growth of computer usage demonstrates a change in the means of operation.

FIG 2.3 OUTLINE ORGANISATION CHARTS AT 1980

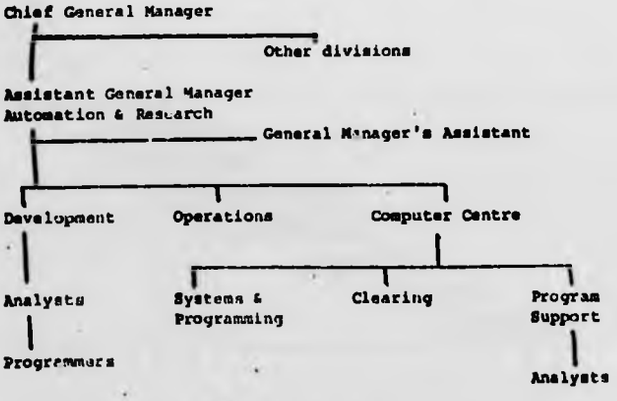
BANK OF SCOTLAND



ROYAL BANK OF SCOTLAND



CLYDESDALE BANK



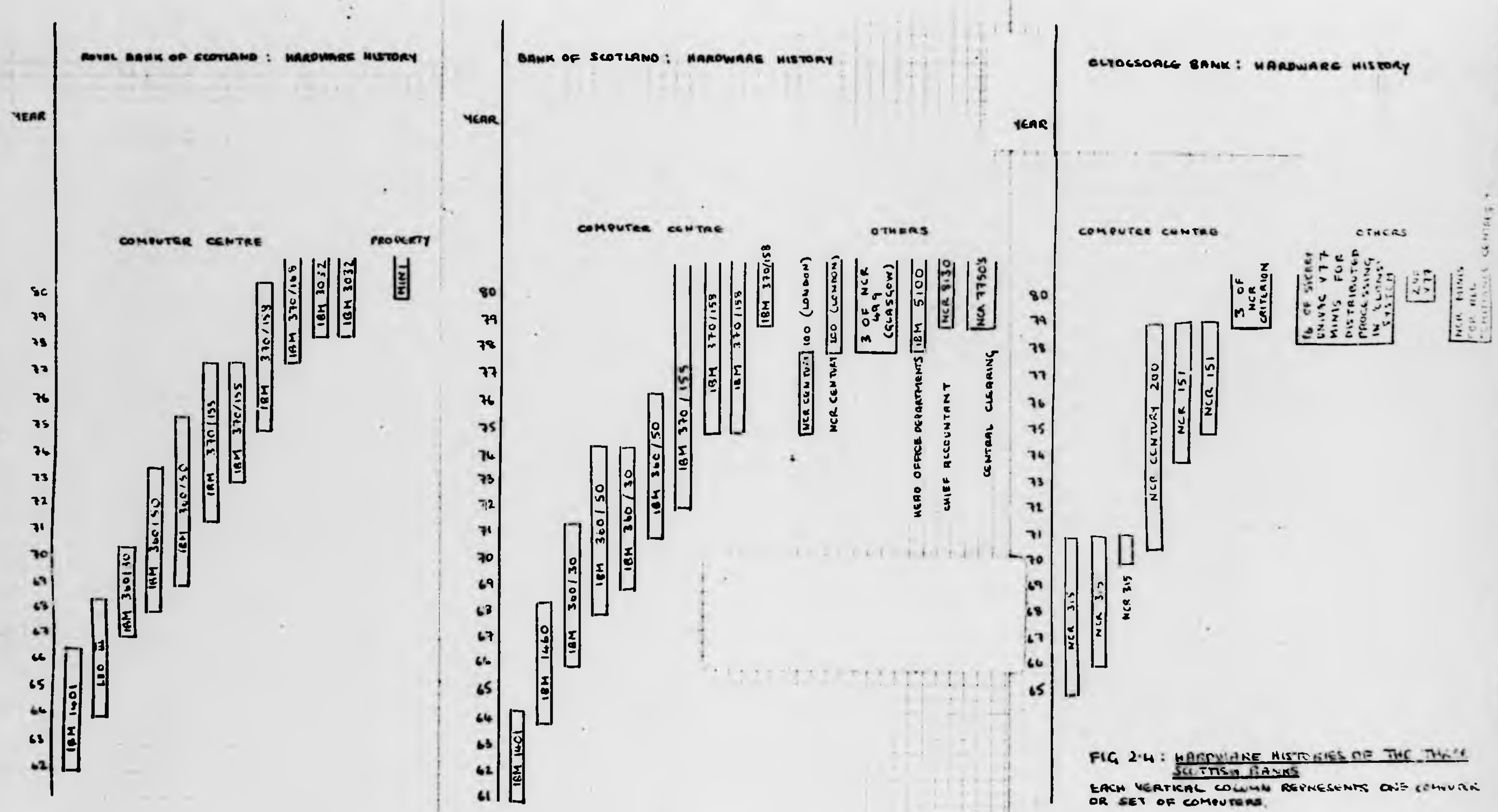


FIG 2·4 : HARDWARE HISTORIES OF THE THREE SCOTTISH BANKS
EACH VERTICAL COLUMN REPRESENTS ONE COMPUTER OR SET OF COMPUTERS.

YEAR	RBS	BS	CB
71	538	421	361
72	513	421	360
73	501	420	362
74	495	420	367
75	488	411	366
76	487	397	367
77	487	385	368
78	487	385	371
79	487	377	375
80	485	377	375

NUMBER OF BRANCHES OF THE SCOTTISH BANKS IN BRITAIN

TABLE 2.5

NOTE: It can be seen from TABLE 2.5 that the Royal Bank of Scotland, and the Bank of Scotland have both decreased their numbers of branches over 71 - 80, whereas the Clydesdale Bank has increased its numbers. In part this difference is due to the fact that the first two Banks, formed by mergers at the beginning of the decade, were able to follow a policy of rationalisation of branches. In addition the Clydesdale Bank, formed considerably earlier out of a West of Scotland bank, and a northeastern bank, has followed a policy of expansion in areas in which previously it had only a minor presence. The proportional changes are small in comparison with the proportional changes in non-retail management.

In Section 3.3 and TABLE 8.1 it is seen that the Scottish Clearing Banks carry out the bulk of clearings in Scotland, and in fact operate the Scottish Clearing System. Moreover, as seen in Chapter 5, they operate comparable information systems. Marketing differences are subordinate to these common aspects.

Chapter 2 : Notes and Bibliography

1 The reader must remember that this volume is not a thesis on history and certain innocuous liberties may be taken for the sake of clarity. William Paterson was not directly involved in the founding of the Bank of Scotland, but society in the late seventeenth century was by nature limited in extent, with a handful of upper class families dominating the finance and ideology of both Edinburgh and London. Thus it is extremely unlikely that the actual founders of the Bank of Scotland, having strong connections in London, were not influenced by Paterson's ideas. In fact, they very probably knew him personally. The Royal Bank does see Paterson as its direct grandfather.

2 "Basics of Banking" S Valentine and S Mason. Hodder & Stoughton 1976

3 "The Bank of Scotland 1695 - 1945" Charles Malcolm. R & R Clark, Edinburgh 1945

4 "The Royal Bank of Scotland 1727 - 1977" The Royal Bank John Bartholomew & Son 1977

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8 "The Royal Bank of Scotland, 1727 - 1927" Neil Munro RBS 1927.

9 "Commentary" p 1161. The Banker 1970

10 "The Banks after disclosure" pp 279 - 293. The Banker 1970.

11 "Scottish Banks in 1971". F S Taylor. Scottish Banker's Magazine 1972.

12 "Credit Controls - the new system" pp 122 - 129 Scottish Banker's Magazine 1971

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15 Annual Reports of the Clydesdale Bank Ltd.

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19 "Sterling unchained" p66 The Economist October 27 1979

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22 "The Wilson Report Considered". Michael Blanden
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Dissertation for University of Edinburgh. May 1977

24 "Personal Finance and Services"
M G Wilcox, in "The Business of Banking"
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Chapter 3 : Information, Production and Cost

In discussing the operational needs of the Banks, interviewees quoted specific aims, such as "completing the paper clearings on time" or "designing a standing order system" or "setting up a working Cash Issuing Terminal system" and so on. The objectives of staff were immediate, requiring specific action. Statements such as "Banks exist to make profits" were regarded as too remote from daily work to be meaningful. Although nowhere in the Banks did the author meet with any reference to information production as the fundamental operational need of all users, this was the only common requirement for all immediate and long-term objectives. Therefore, the author identified the one fundamental operational need as being the timely production of information for the variety of users listed below.

On commencing study in the Banks, the author discovered that there was an awareness of a problem concerning the Clearings, but no definition of the problem existed.

The examination of the clearing and accounting systems of the three Banks, in the light of the requirements for information, has allowed identification of a central problem in the Clearings. Clearings have as their principal purpose the completion of transactions involving money transmission. In order to complete transactions, the data about the transactions must be collected, processed and distributed to the relevant parties, either two separate Banks or two branches of one bank. In all cases where clearing occurs there is necessary a transfer of data across an interface between these two Bank parties. Data must pass out of one information system, and smoothly enter another. In the current mode of operation the exchange of paper clearings is seen, not as an exchange of data, but as an exchange of orders to pay. There is nothing incorrect about this viewpoint, but as a result, at the interface between crossing bank and paying bank the crucial data transfer is a by-product of the passing over of bundles of paper. This being the by-product and not the central purpose of the interface system, the system is not designed for effective data transfer. The computer is used to assist the paper sorting, but is virtually uninvolved in the data transfer. This is further examined in Section 5.4 and in Chapter 9.

The information system approach is central to the identification of this, and other major problems, as well as being crucial to the more general aims of the thesis, and is therefore discussed in this early chapter.

3.1 Information and Information Systems

In retail banking, interest or money transmission are offered to customers for the use of their funds, and customer accounts are maintained. For these functions data is required. This raw data, consisting of random facts, which can be words, numbers and their association, is processed into information. Information is organised data, and is of use and of value only when it is communicated to a relevant user. The creation of information for specified users is carried out by an Information System.

In Banking, the information system has had, since the earliest days, an input of deposits placed, advances made, interest applied or collected, payments to and from different parties, assets on hand, etc, while there has always been a requirement for adequate information on the state of funds, the reliability of clients, the completion of transactions, the ruling interest rates etc. The information system, initially clerical, using journals, ledgers, word-of-mouth, paper vouchers, letters and so on, produced the various experience, schedules and customer accounts which constitute the information requirement for a profitable system.

The users of the Banks' information systems are many, ranging from the customer, to general management, as demonstrated in TABLE 3.1.

USER	SOME USES
CUSTOMER	Keeping track of accounts - balance, charges, interest paid and received, payments made, source/destination of payments, incidence and dates of payments etc.
BRANCH	Processing transactions. Tracing transactions. Completing payments to and collections from other Banks. Assessing customer creditworthiness. Making advances. Giving financial advice etc.
HEAD OFFICE	General management. Marketing. Investment direction etc. Completing inter-bank financial transfers. Assessing risk etc.
INTERNAL AND EXTERNAL AUDITORS	Fraud prevention.
INLAND REVENUE	Tax assessment.
BANK OF ENGLAND	Monetary direction.

SOME USERS OF BANK INFORMATION SYSTEM TABLE 3.1

In the general commercial environment, to date, real information systems have been concerned with the production of specific user requirements, and virtually all texts on information systems describe data processing techniques. The theory of information is seldom treated, and when it is, is done so from the point of view of its implications for specific system design.[4] It has therefore been necessary for the author to examine real information systems and to abstract from these the attributes of data and information, and from these to build up the requirements for an ideal information system.

Comparing a system for the production of information with a factory process, data is seen as a collection of facts, figures and their associations, in raw, random order; the data must be purified - or validated; it must be processed to its final useful form, at which stage it is information.

There follows below an outline of an ideal information system, incorporating a number of the author's definitions. These definitions are used throughout this thesis, first to describe aspects of current systems, and secondly to propose a closer approach to an ideal system. (See Chapter 9).

Like any industrial product, for its creation, information requires the collection of raw material (the data) its purification, that is the removal of wrong and corrupt data, a store for the material, a process which converts the data to its final form, and a mode of distribution to consumers (the information users). Unlike industrial products, it must be possible to reconstruct, or validate, information once it has been created. For this to be possible, all the data that enters the system must be stored so that it can be retrieved and re-used if necessary.

An INFORMATION SYSTEM has the following components:-

1] a data collection system.

2] a data validation system.

3] a data processing system.

4] an information output system.

5] an information distribution system.

Such a system can produce information, but cannot reconstruct it. For a COMPLETE INFORMATION SYSTEM there is therefore an additional requirement

6] a data storage and retrieval system.

This is an EFFICIENT RETRIEVAL SYSTEM if required data can be uniquely identified by the retrieval system, that is

7] there is one-to-one relationship between retrieval codes and data to be retrieved.

None of these aspects requires computers. However, to be useful, an information system should also be READILY AVAILABLE, that is

8] information can be produced from raw data in a timely and cost-effective manner.

Where large volumes of data are involved data processing computers are particularly suited for information systems. In such cases, a readily-available system is possible using a COMPUTER BASED INFORMATION SYSTEM, this being an information system in which the computer provides for all the flow, storage and processing of data and for information output. The computer need not, however, cater for all the collection or all the distribution as these are peripheral activities. They are, however, a natural extension of a computer based system.

3.2 The Source of Bank Profits

Banks are profit-making organisations. The profits in Retail Banking are made, traditionally, by advancing loans from deposits which are attracted by the offering of interest and of information-based services such as account keeping, and money transmission. Computerisation can contribute towards profit-making by reducing the costs of the services.

Set out below are two models of how a general bank produces profits.

(i) a model of the profits made on overall funds, and

(ii) a model of how individual accounts contribute to profits.

These models can be used to demonstrate why, during the 1960's and 1970's, cost-reduction was considered important by Bankers.

The cost constraints within which bank information must be produced are determined by the potential operating profit of the bank. Whether particular business should be retained or taken on is determined by its marginal profitability based on average cost to the bank of each of the work units it generates, and the average income it attracts.

(i) Overall Funds Model

Crudely a bank can be seen as taking deposits D, and making advances A. Then

* On a proportion p of deposits, interest is paid at effective annual rate r.
* On a proportion (1 - p) of deposits, effectively no interest is paid, and a charge, C, is made for services (current accounts).
* On advances (which must be strictly less than deposits) interest is paid at an effective rate s by borrowers, where $s > r$.

During the year a Bank has expenses E.

For a real Bank $C \ll E$

In any year, the Bank has income:-

$$As + C$$

It has expenditure:-

$$Drp + E$$

If advances are a constant proportion k of D then the net annual income to the Bank is

$$kDs + C - Drp - E = Z$$

where Z = Profit in the year.

This can be re-expressed as

$$Z = (C - E) + D(ks - rp) \qquad (1)$$

Profit per unit of deposit can be described by the equation

$$\frac{Z}{D} = (ks - rp) + \frac{(C - E)}{D}$$

(ks - rp) ↑ an interest component; $\frac{(C - E)}{D}$ ↑ a cost component

$\frac{(E - C)}{D}$ can be interpreted as the net relative cost N of taking deposits. E consists of bank expenses, such as salaries and overheads. At 1980, the amount taken in charges in one bank amounted to less than 2% of salaries. Thus C is very much less than E.

So N is approximately equal to $\frac{E}{D}$

E can be considered as having a fixed part, and a part dependant on the level of deposits.

In other words $E = a + b D$ a, b constants.

Then $N = \frac{a}{D} + b$

Thus, increasing deposits should decrease relative costs. In practice, if deposits increase substantially (which would usually be due to expanding the customer base), more staff and premises would be required, so that the net relative cost N of taking deposits can be considered to be, at any time, substantially fixed.

Thus, $\frac{Z}{D} = (ks - rp) - N$ (2)

In Section 2.2 attention was drawn to the restrictions and controls on banking during the seventies. In equation (2) an upper limit on k is determined by the Government. Also p depends on market behaviour, which, in the perception of Bankers throughout the greater part of the sixties and seventies, could not be influenced.

In addition, s, r and the margin between them were seen as effectively determined by the ruling minimum lending rate. It thus appeared to Bankers that the only control they could exercise over profitability was through N, the relative cost of taking deposits.

It should also be noted that profitability is decreasing as p increases, this being the ratio of interest bearing deposits to all deposits. Traditionally, for retail deposits this ratio is considerably higher in the Scottish Banks than in the English Banks (0.55 against 0.45).

The net result of this analysis is that the Scottish Banks should be aware of the importance of containing or reducing gross expenses E in order to maintain profits, for the same deposits.

A further consideration is that the profit per deposit depends on the margin between s and r.

Let $m = s - r$

Then

$$\frac{Z}{D} = k(r + m) - rp - N$$

$$= r(k - p) + km - N$$

Hence $\frac{Z}{D}$ is a linear function of m.

It was common Banking practice in the early seventies for m to be a constant, independent of s. This meant that, as s increased, the relative margin $\frac{m}{s}$ decreased.

While market rate is increasing, customers are apparently aware of m, the actual margin. However, when interest rates decrease, customers become aware of the relative margin $\frac{m}{s}$ and expect this to remain constant, whereas, to maintain the profits on the interest-bearing proportion of their funds, banks require the relative margin to increase to its former level.

Since $\frac{\partial}{\partial r}\left(\frac{z}{D}\right) = (k - p) \sim 0.25$

whereas $\frac{\partial}{\partial m}\left(\frac{z}{D}\right) = k \sim 0.8$

profits are more seriously affected by a reduction in m than by the same reduction in r.

Recently, there has been market pressure to reduce margins while interest rates are reducing.

Thus, reducing interest rates threaten to cause a squeeze on bank profitability because in addition to loss of interest, relative margins become restricted. The fluctuating nature of interest rates over the decade 1970 - 1980 shown in Fig 3.1 demonstrates adequate cause for concern about squeezed margins.

Since, from (1) and (2) it can be seen that profits increase as expenses decrease, and since Bankers felt that they could control this aspect of their profitability, cost containment was regarded as essential.

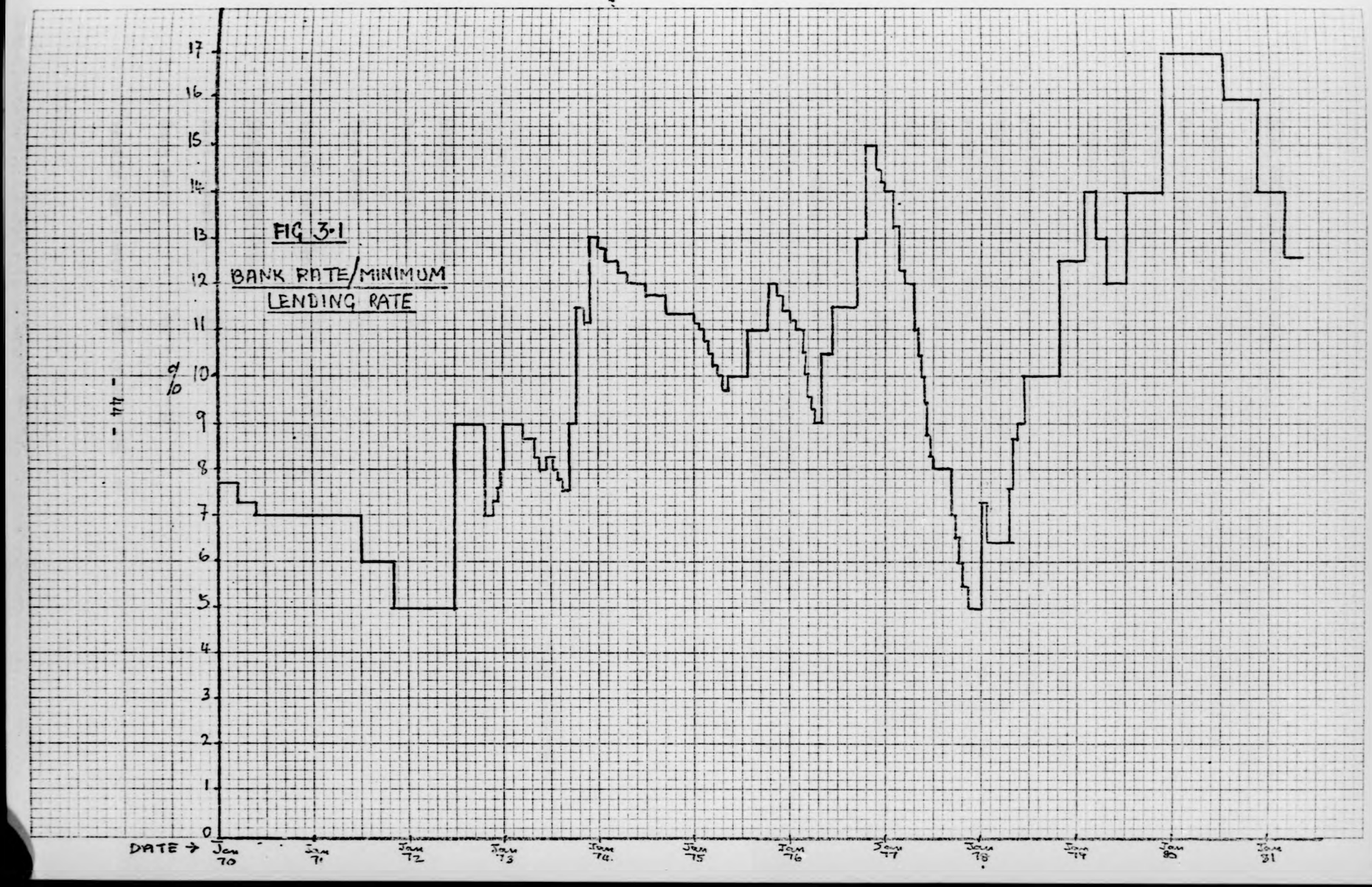


FIG 3·1
BANK RATE/MINIMUM LENDING RATE
% p.a.
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DATE →
Jan 70
Jan 71
Jan 72
Jan 73
Jan 74
Jan 75
Jan 76
Jan 77
Jan 78
Jan 79
Jan 80
Jan 81

(ii) Individual Accounts Model

Expenses can only be contained if their causes are known. In retail banking one obvious cause is the production of information for individual accounts. In the following analysis only marginal costs are considered, because retail Banks are, by nature, high fixed-cost institutions, due to the requirements for property maintenance and salary payments.

It will be assumed that no float is held in an account (either positive or negative). Such a float would increase profitability. Its presence in this analysis would mask the principle. It is assumed that an input I is made to an account at regular intervals, and that this is withdrawn evenly over the period between deposits. The analysis is then very similar to a stock control question.

Let: I = amount of regular input into an account (either deposit or current)

Hence. Average balance = I/2.

v = number of inputs per year

w = number of withdrawals per year

s = effective rate of return on advances per year

r = effective gross rate paid to deposit account holders per year

m = s - r

e = cost of an input (deposit or current)

f = cost of a deposit account withdrawal

g = net cost of a cheque withdrawal (actual cost less charge collected)

h = cost of keeping an account on record per year.

Deposit account

Bank receives	$\frac{Im}{2}$
Bank pays	$ve + wf + h$
Profit (or loss)	$\frac{Im}{2} - ve - wf - h$

Current account

Bank receives	$\frac{Is}{2}$
Bank pays	$ve + wg + h$
Profit (or loss)	$\frac{Is}{2} - ve - wg - h$

Hence it can be seen in both cases

profit increases with average balance, rate of interest on advances

or interest differential and

profit decreases with number of movements.

Assuming h is negligible, the level of deposit required for profitability under various cost and interest regimes can be calculated.

Deposit Accounts

For zero profit $\frac{Im}{2} = ve + wf$

So $I = \frac{2}{m}(ve + wf)$

By the nature of a deposit account there is strong argument for claiming that deposits and withdrawals cost the same to the bank. Hence the equation reduces to

$$I = \frac{2e}{m}(v + w)$$

TABLE 3:2 : COMMON ACTIVITY PROFILES OF DEPOSIT ACCOUNTS PER ANNUM

PROFILE	v	w	v + w
A	2	2	4
B	2	12	14
C	12	12	24
D	12	52	64
E	52	52	104

Since m is likely to be 0.04 or 0.06 per annum, this produces the relationship between I and e shown in FIG 3.7 and FIG 3.8.

Current Accounts

For current accounts the break-even condition is

$$I = (ve + wg)\frac{2}{s}$$

Unlike the deposit account case, this cannot be simpliied. Thus, in Table 3.5 the costs resulting from likely combinations of v, e, w and g are set out. Then in Table 3.6, the break-even values of I for current accounts for s = 0.08 s = 0.12 and s = 0.16 are tabulated.

From Table 3.6 and Figs 3.7 and 3.8 it can be seen that it is considerably easier to attain a profit-making balance on a current account than on a deposit account, in terms of the level of regular deposit required.

For the same activity, a current account is considerably more profitable than a deposit account. In both cases, though, costs greatly affect the level of balance required for profitability. Hence it is in the interest of banks to contain costs. In particular, it is in the interest of banks to improve costs on deposit accounts, or remove the deposit accounts which are causing them a loss. This, of course, must be considered only against the background of other profitable connections with the customer in question.

The remainder of this chapter considers (a) whether any cost reductions as a result of computerisation can be seen in the profit profiles of the Scottish Banks, and (b) what changes have taken place in the workload of the Banks, so that, in later chapters, an assessment can be made of the order of magnitude of cost changes.

TABLE 3:5

CURRENT ACCOUNTS Expenses associated with movements under various likely regimes

	v			w		
ve	12	52	wg	12	52	100
e £0.10	£1.20	£5.20	g 0	0	0	0
e £0.50	£6	£26	g £0.10	£1.20	£5.20	£10
e £1.00	£12	£52	g £0.50	£6	£26	£50

ve + wg	g	w 12	52	100
v = 12, e = £0.10	0	£1.20	£ 1.20	£ 1.20
	£0.10	2.40	6.40	£11.20
	£0.50	7.20	27.20	51.20
= £0.50	0	6.00	6.00	6.00
	£0.10	7.20	13.20	16.00
	£0.50	12.00	32.00	56.00
= £1.00	0	12.00	12.00	12.00
	£0.10	13.20	17.20	22.00
	£0.50	18.00	38.00	62.00
v = 52 e = £0.10	0	*	5.20	5.20
	£0.10		10.40	15.20
	£0.50		31.20	55.20
= £0.50	0	*	26.00	26.00
	£0.10		31.20	36.00
	£0.50		52.00	76.00
= £1.00	0	*	52.00	52.00
	£0.10		55.20	62.00
	£0.50		78.00	102.00

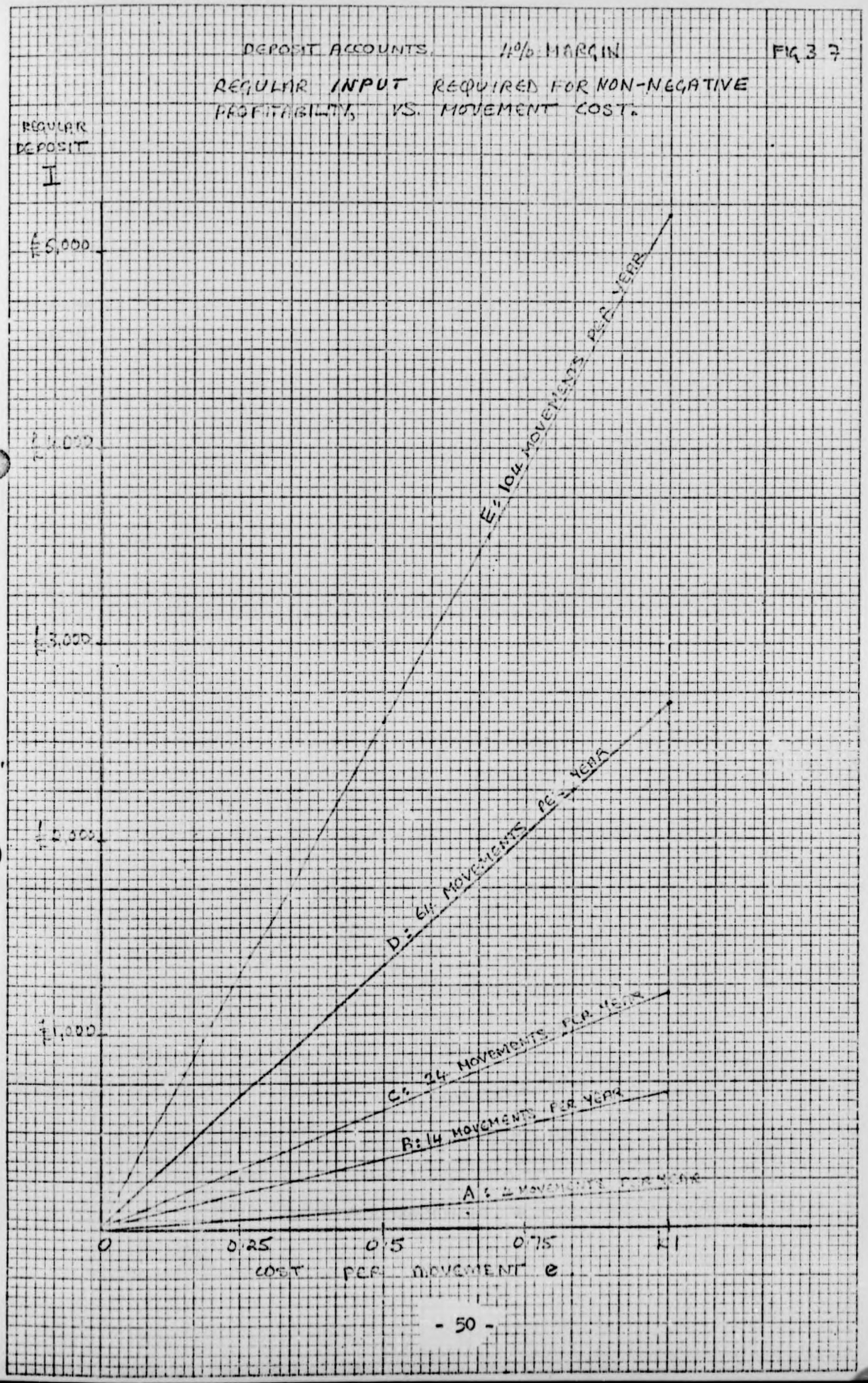
* It is extremely unlikely for a current account to have a higher frequency of deposits than withdrawals.

CURRENT ACCOUNTS BREAK-EVEN DEPOSIT I

TABLE 3:6

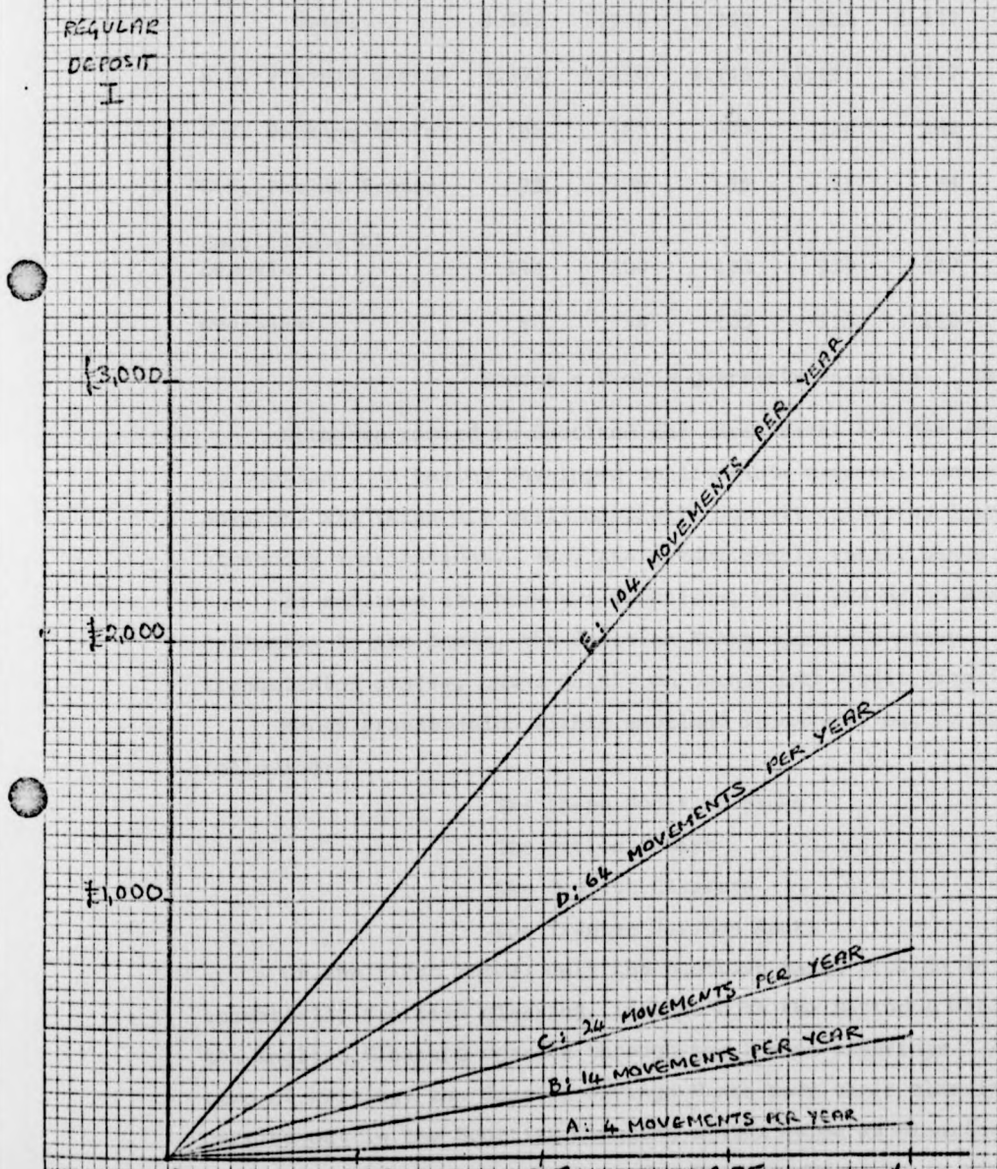
			S = 0.08			S = 0.12			S = 0.16		
	£ e	£ g	w 12	w 52	w 100	w 12	w 52	w 100	w 12	w 52	w 100
v = 12	0.10	0	£15	15	15	10	10	10	8	8	8
		0.10	30	80	140	20	53	93	15	40	70
		0.50	90	340	640	60	227	427	45	170	320
	0.50	0	75	75	75	50	50	50	38	38	38
		0.10	90	165	200	60	110	133	45	83	100
		0.50	150	400	700	100	267	467	75	200	350
	1.00	0	150	150	150	100	100	100	75	75	75
		0.10	165	215	275	110	143	183	83	108	138
		0.50	225	475	775	150	317	517	113	238	388
v = 52	0.10	0	*	65	65	*	43	43	*	33	33
		0.10		130	190		87	127		65	95
		0.50		390	690		260	460		195	345
	0.50	0	*	325	325	*	217	217	*	163	163
		0.10		390	450		260	300		195	225
		0.50		650	950		433	633		325	475
	1.00	0	*	650	650	*	433	433	*	325	325
		0.10		690	775		460	517		345	388
		0.50		975	1275		650	850		488	638

* See Table 3.5.


DEPOSIT ACCOUNTS. 1½% MARGIN
FIG 3 7
REGULAR INPUT REQUIRED FOR NON-NEGATIVE PROFITABILITY VS. MOVEMENT COST.
REGULAR DEPOSIT
£5,000
£3,000
£1,000
E: 104 MOVEMENTS PER YEAR
D: 61 MOVEMENTS PER YEAR
C: 24 MOVEMENTS PER YEAR
B: 14 MOVEMENTS PER YEAR
A: 6 MOVEMENTS PER YEAR
0
0·25
0·5
0·75
1
COST PER MOVEMENT e

DEPOSIT ACCOUNTS 6% MARGIN Fig 3·8

REGULAR INPUT REQUIRED FOR NON-NEGATIVE PROFITABILITY VS MOVEMENT COST.



3.3 The Profits Of the Scottish Banks

About 85% of all deposits in the Scottish Clearing Banks have been placed there by the private sector, as shown in Table 3.8.

TABLE 3:8

Liabilities of the Scottish Clearing Banks : Deposits £m

	1979			1980		
	Oct	Dec	Mar	Jun	Aug	Oct
Total	3,860	3,946	4,002	4,232	4,439	4,691
U.K. Private Sector	3,393	3,456	3,448	3,669	3,717	3,987
U.K. Banking Sector	165	163	177	138	162	165
U.K. Public Sector	78	79	89	81	74	80
Certificate of Deposit	144	150	183	229	367	344
Overseas	80	98	105	115	119	115

Source : B of E Quarterly Bulletin. Dec. 1980

Although rooted in Scotland the three Banks are not exclusive to Scotland, in having developed considerable external connections. However, all three are still basically deposit gathering loan advancing institutions. They are predominantly retail banks.

In addition to these two functions, which are by no means exclusive to the banks, the Scottish Banks operate a money transmission system, based mainly on cheque and credit clearings.

Money transmission within Scotland is carried out by the following:-

The three Scottish Banks
The National Giro
The English Clearers
The Trustee Savings Banks

Of the first three, only the Scottish Banks provide an essentially Scottish clearing, in that both the National Giro and the English Clearers operate through the London clearings. At the time of writing, the Trustee Savings Banks have their clearings carried out in the Scottish Clearing system using as Clearing Agents branches of the Scottish Banks. The Scottish Banks do in addition transmit items to and receive items from the London Clearings.

The profits and the computerisation of the Banks must be seen in the light of the increases in their business.

Banks have come under fire in recent years for making excessive profits at the cost of the rest of the economy, particularly from the "windfall" effect of high interest rates received for money in non-interest bearing current accounts. Whether the Scottish Banks have in fact made excessive profits during the late seventies can be judged by comparison with the early seventies when such claims were not made.

Bank profits can be considered in a number of ways:

1) Gross profits in money terms as stated in annual reports (FIG 3.2)
2) Profits at 1970 prices over the decade, deflated using the retail price index (FIG 3.3) (RPI is given in Appendix A)
3) Gross profits as a proportion of average deposits for the previous year (FIG 3.6).

Table 3.7 lists the declared profits of the banks excluding associated companies. This is seen to have risen by a factor of about 4 in the case of the Royal Bank and the Bank of Scotland, and a factor of 10 in the case of the Clydesdale Bank in the decade 1970 - 1980. Reduced to 1970 prices the position is seen to be more erratic, but with a definite upward trend, particularly evident in the case of the Clydesdale Bank. However, a factor of 2 over the decade can be used as a rough indicator of profit increases. This must be compared with a real increase in deposits, indicated in FIG 3.5.

The results of the comparison in TABLE 3.7 - actually calculated on average deposits and profits in money terms, not deflated - are shown in FIG 3.6, from which it can be seen that, using this indicator of profitability, only the Clydesdale Bank can be shown to have increased returns over the decade, both the other two banks showing a falling trend. It must be commented, however, that the ratio of profits to average deposits is not necessarily accepted by bankers as a real indicator of profitability, although it is in line with the analysis at the beginning of this chapter. Because of the fact that annual account dates of the Banks differ, the ratios produced in Table 3.7 cannot be used for inter-bank comparisons.

It must be commented in addition that the actual business, in real terms, carried out by the banks has increased over the decade, which once again suggests that increased profits should be expected, not from windfall effects, but from increased business.

Since in this analysis, two banks show a decline in profitability, and one an increase, improved profitability cannot be ascribed to computerisation per se as all three banks have followed computerisation programmes. Neither can loss of profitability be so ascribed. The major difference possibly lies in the structure of these Banks - one predominantly retail, making enhanced profits in recent years when the retail market has been very attractive - the other two more involved in wholesale and international business.

The cost profile of the Banks should, on the other hand, be capable of relation to computerisation. Figures for detailed analysis have not been available. However, an estimate of $\frac{Z}{D}$ for the decade for the Royal Bank of Scotland is shown in FIG 3.9. This is based on staff figures published for the Royal Bank, combined with the following figures from the "Annual Report to Staff 1980" of the Bank of Scotland:-

	£m
Total salaries to staff	38.4
Indirect staff costs	16.9
Non-staff costs	33.5

This suggests that overheads were 130% of direct staff costs at 1980.

In Fig 3.9 it is assumed that 130% was typical for the whole decade, and was also applicable to the Royal Bank.

From FIG 3.9 it can be seem that $\frac{Z}{D}$ has fluctuated around 6% per unit of deposit. (This suggests a lower acceptable limit for (ks - rp), unless further cost savings are achieved).

It should be noted that the graph is of dubious validity at 1972, reflecting the assumption on overheads. It is likely that total salaries were, at that time, a higher proportion of the total expenses.

TABLE 3:7

PROFITABILITY : (YEAR PROFITS/AVERAGE YEAR DEPOSITS)%

	YR	(1) £m AVERAGE DEPOSITS	(2) £m PROFIT	(3) £m RATIO %
RBS				
YEAR TO SEP 30				
	70	463	11.24	2.43
	71	491	9.80	2.00
	72	605	10.45	1.73
	73	802	14.65	1.83
	74	1,032	22.68	2.20
	75	1,266	24.50	1.93
	76	1,426	31.48	2.21
	77	1,559	34.05	2.18
	78	1.787	29.69	1.66
	79	2,117	40.70	1.92
	80	2,576	44.80	1.74
B of S				
YEAR TO 28 FEB				
	71	365	8.77	2.40
	72	399	9.73	2.44
	73	508	12.69	2.50
	74	682	20.59	3.02
	75	782	13.88	1.78
	76	856	21.24	2.48
	77	1,015	27.33	2.69
	78	1,240	28.19	2.27
	79	1,479	32.11	2.17
	80	1,725	39.80	2.31
	81	2,195	44.40	2.02
CB				
YEAR TO 31 DEC				
	70	260	4.18	1.61
	71	284	4.20	1.48
	72	340	6.12	1.80
	73	448	9.02	2.01
	74	555	7.94	1.43
	75	615	8.74	1.42
	76	674	10.80	1.60
	77	747	14.00	1.87
	78	839	20.72	2.47
	79	995	30.80	3.09
	80	1196	24.12	2.02

SOURCE OF COLUMN 2 - ANNUAL REPORTS
SOURCE OF COLUMN 1 - LINEAR INTERPOLATION OF ANNUAL REPORT FIGURES.

FIG 3·2

PROFITS (EXCLUDING ASSOCIATED COMPANIES) OF SCOTTISH CLEARING BANKS, FROM ANNUAL REPORTS.

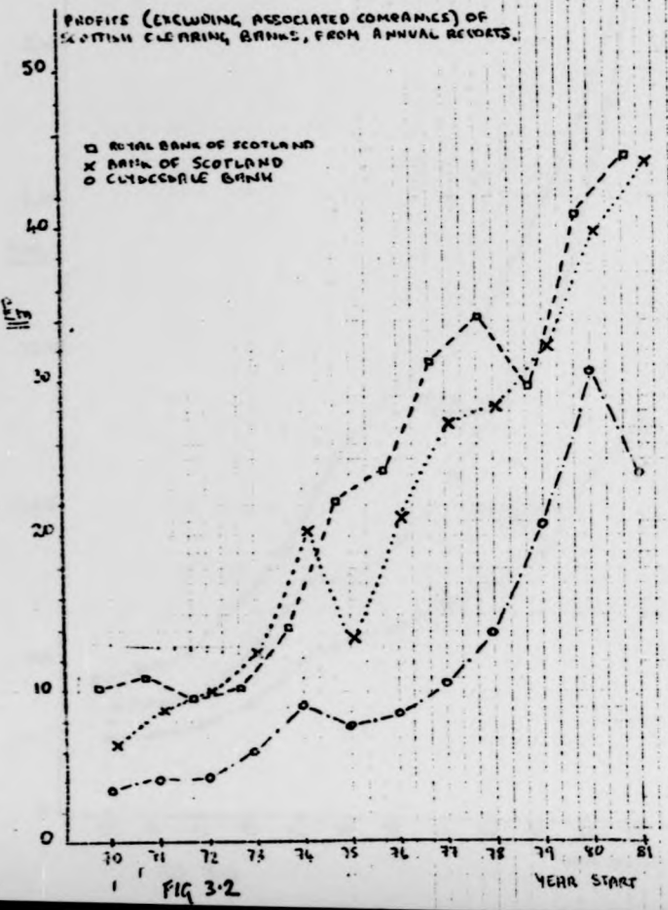


FIG 3·2

FIG 3·3

SCOTTISH CLEARING BANKS
PROFITS AT JANUARY 1970 PRICES 1970–1980.
(EXCLUDING ASSOCIATED COMPANIES)

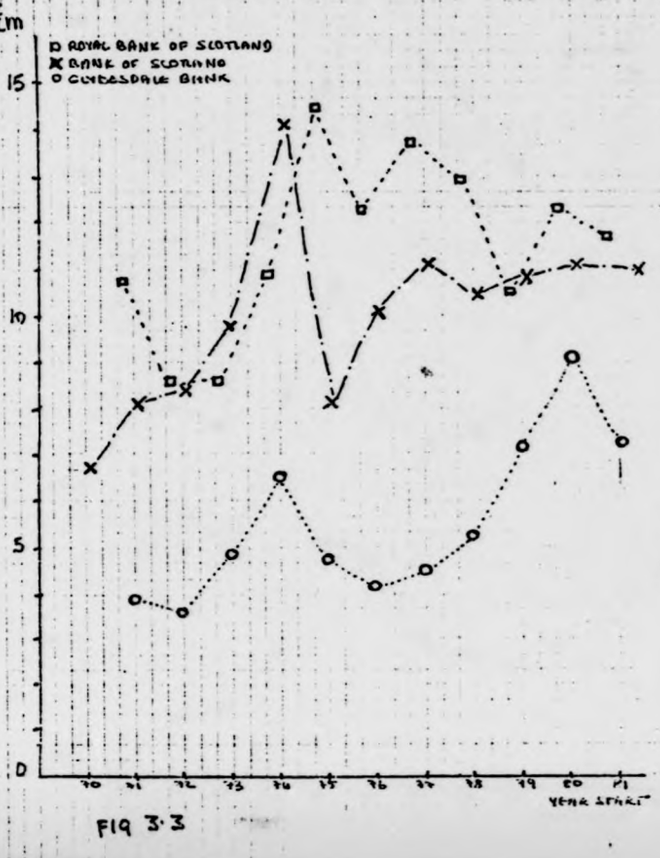


FIG 3·3

FIG 3·4

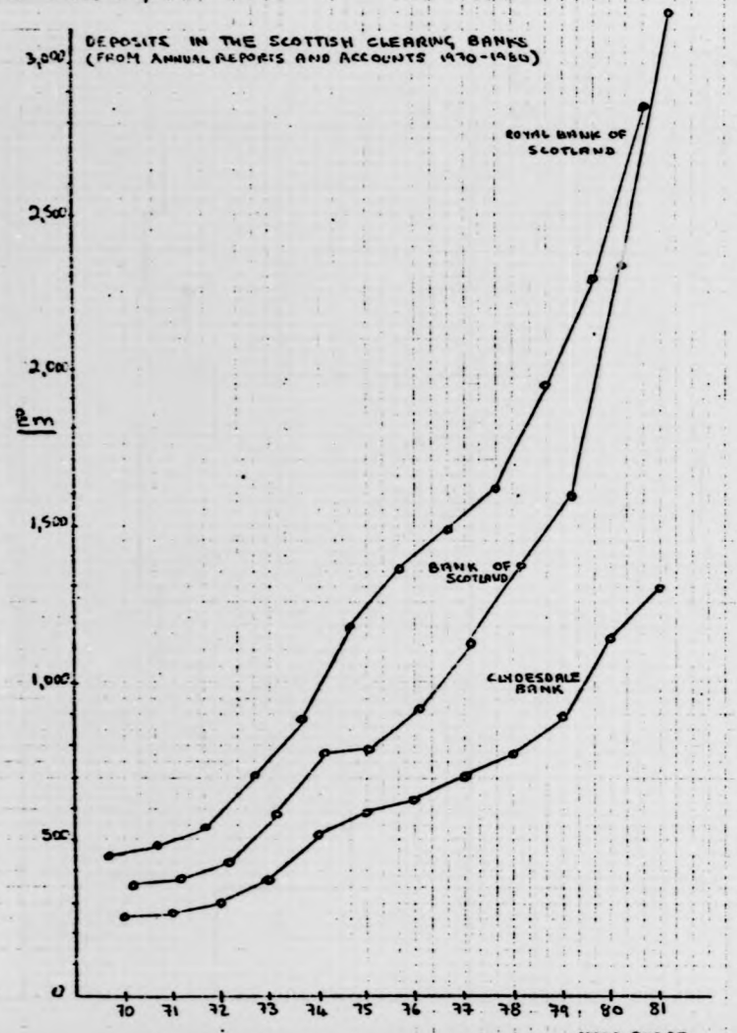


FIG 3·4

FIG 3·5

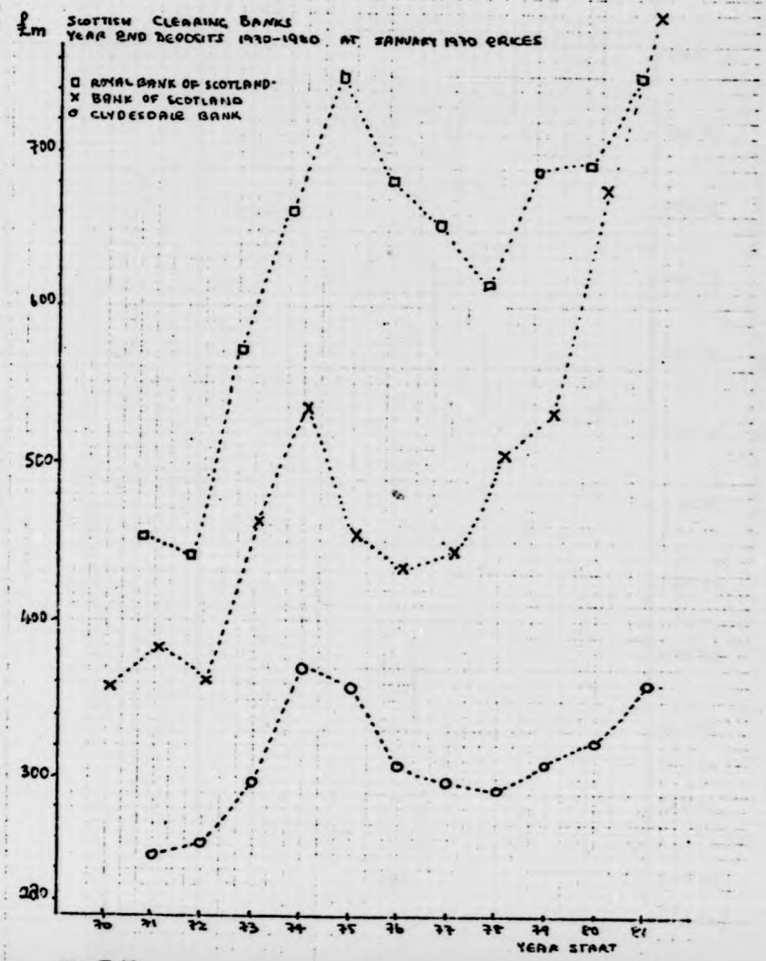
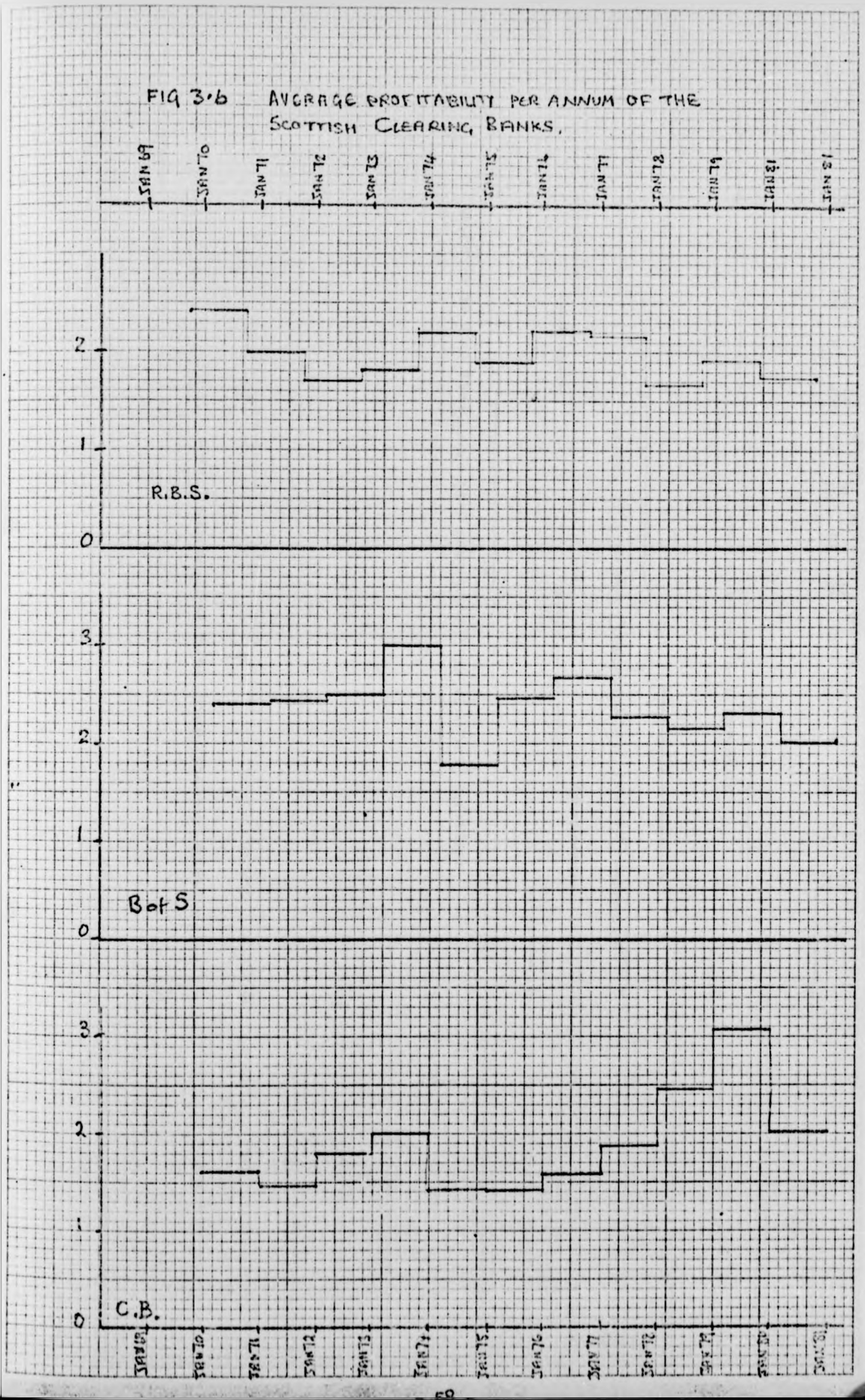


FIG 3·5

FIG 3.6 AVERAGE PROFITABILITY PER ANNUM OF THE SCOTTISH CLEARING BANKS.



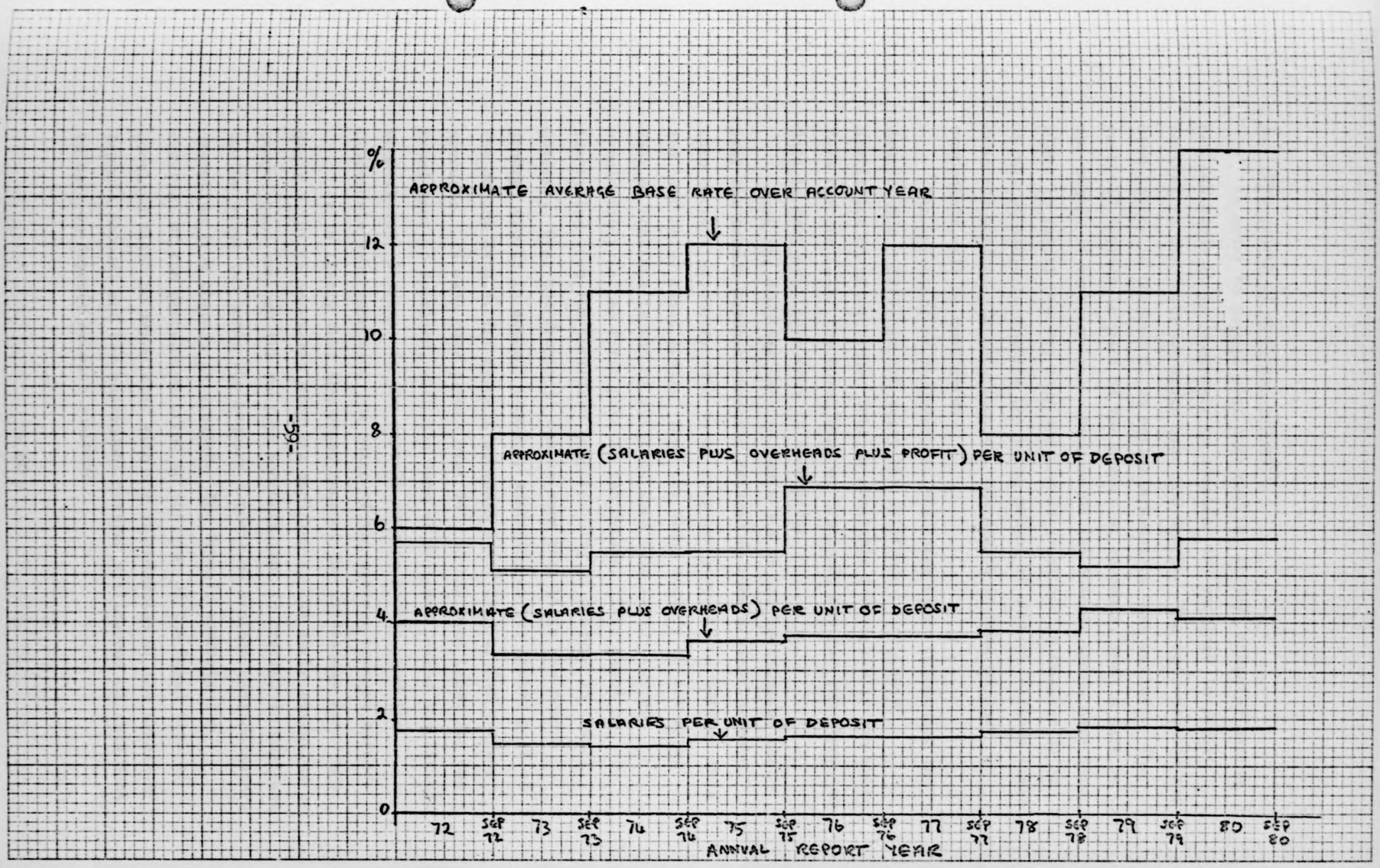


FIG.3.9 POSSIBLE PROFITS AND COSTS PROFILE FOR THE ROYAL BANK OF SCOTLAND.

3.4 The growth of customer accounts

In order to assess what cost saving, if any, computerisation has achieved, it is necessary to consider the workload in retail banking in the Scottish Banks over the decade. The observations are used later, in Chapter 6, to estimate possible cost savings. The workload depends in part on the number of accounts, and in part on the number of transactions. Because of the changes which have taken place in retail banking over the decade (outlined in Chapter 2) it is not possible to compare the total amount of work at various times over the period. In this section, the growth in some of the components will be considered.

The existence of computers in the three banks throughout the decade 1970 - 1980 has not meant the existence of reliable statistics on accounting. Data is available for virtually the whole term for one bank, the Royal Bank of Scotland, but for the other two data is only available from 1974 onwards.

From the combined data in TABLE 3.9 it can be inferred that over the decade deposit accounts existed in much greater numbers than current accounts, with their relative proportions between 1974 and 1980 being about 1.4:1. From the older records of the Royal Bank of Scotland it can be inferred that this ratio dropped considerably in the first part of the decade. This might be identified with the increased acceptability of cheques in retail outlets. Over the decade it can be seen that there has been a general growth in account numbers, averaging in the latter part of the decade 6% p.a. for deposit accounts and 7.1% p.a. for current accounts. In each case growth over 74 - 80 has been least for the Royal Bank of Scotland, with the Bank of Scotland taking the largest proportional increase in the deposit account market, and the Clydesdale Bank improving its share of the current account market.

It is likely that the experience of the Clydesdale Bank (see TABLE 3.10) is connected with its decision in the early seventies to remove bank charges for current accounts kept in credit, in contrast to the other two banks who require a positive minimum balance before exemption from charges is granted. For deposit accounts the reversal of the decreasing trend in the case of the Royal Bank of Scotland might be associated with the introduction of the Cashline Deposit Account and the consequent greater willingness of this bank to take on deposit account business.

After a sudden bulge in the ratio of deposit accounts to current accounts in the Bank of Scotland there is a shedding of market share, which is likely to be associated with the awareness of the costly nature of deposit accounts, especially in the Bank of Scotland where as yet the processing of these accounts is not fully computerised.

A significant feature of deposit account profitability is the reducing value of average balances in real terms, (which increases the proportion of unprofitable accounts) set out in TABLE 3.11. One bank estimates that at the level of average balance with 1970 value of £160, given the activity profile of its customers, only 60% of deposit accounts are profitable. Considerably more will enter the unprofitable category if real average deposits continue to remain at their current low levels. It is an attempt to render these accounts profitable which has precipitated the intensive investment in teller terminals in both the Royal and the Clydesdale Banks.

Specific mention could be made of the various specialised accounts such as for roll-over credit. However, long-run comparative data is not available. Nor is there available comparative data on the proportions of business accounts to personal accounts. In this respect it may be remarked that the total of current accounts being 1.7M at 1980 suggests at first sight that the vast majority of the adult population of Scotland must hold bank accounts, contrary to published market research by the Inter Bank Research Organisation and others. It must be borne in mind that, while this figure does include joint accounts, it also includes all business and duplicate accounts.

No data is available in any bank which enables the true extent of duplication to be discovered. A thorough manual search of the records of all the banks taken together alone would at present enable the true level of banking in the population to be determined.

3.5 Transaction and Clearing Volumes

During the decade 1970 - 1980, the growth in cheque numbers has in each bank exceeded the growth in numbers of accounts, so that over the decade the rate of cheque usage per account has also increased, and at 1980 varies from about 90 to 115 per current account, depending on the Bank in question. This has been so in spite of the growth over the term of duplicate and "number-two" accounts held by companies and individuals.

The number of transactions on deposit accounts has grown over the decade at an average annual rate of 8.6%. The growth in current account movements has been even more dramatic as demonstrated in TABLES 3.13 and 3.14.

This increase in the number of movements per account represents an increase in the real cost to a bank of holding an average account on its books. Some of this cost is recovered by bank charges (though proportionately much less in the case of the Clydesdale Bank). However, so little is directly recovered that the Banks are concerned about clearing costs. One bank estimated that in 1980 total collected in bank charges was 0.05% of average deposits.

In the mid-sixties cheque clearing was automated because volumes had reached unmanageable proportions for manual systems, and volumes were expected to increase. In the early seventies, bank giro credits were introduced to divert traffic from the debit clearings (as well as to offer enhanced services to customers). Direct debits were introduced to remove the strain from standing order systems, and BACS giro credits were also introduced to offer an alternative to voucher clearing. All these innovations had a cost motive. They have all, individually, added to the workload in the Banks, although the new systems probably helped to reduce growth in other modes of money transmission.

The number of accounts, and transaction and clearing volumes must be considered when assessing the effects of computerisation on costs. Estimates of the total impact on workload are used in Chapter 6.

TABLE 3.9

NUMBER OF ACCOUNTS HELD IN THE SCOTTISH CLEARING BANKS

	DEPOSIT A/C's : THOUSANDS		CURRENT A/C's : THOUSANDS	
YEAR	TOTAL	% GROWTH ON PREVIOUS YEAR	TOTAL	% GROWTH ON PREVIOUS YEAR
74	1636		1123	
75	1873	14.5%	1247	11.0%
76	2006	7.1%	1332	6.8%
77	2092	4.3%	1396	4.8%
78	2172	3.8%	1470	5.3%
79	2239	3.1%	1579	7.4%
80	2321	3.7%	1698	7.5%
AVERAGE GROWTH 1974 - 1980		D/A 6%		C/A 7.1%

PER BANK		RBS	B of S	CB
	C/A	6.2%	7.6%	8.0%
	D/A	4.7%	8.9%	4.9%

TABLE 3.10 SCOTTISH BANKS RATIO OF NUMBERS OF DEPOSIT TO NUMBERS OF CURRENT ACCOUNTS EXPRESSED AS A DECIMAL

	RBS	B of S	C.B.	TOTAL
74	1.77	1.10	1.49	1.46
75	1.72	1.34	1.40	1.50
76	1.69	1.41	1.36	1.51
77	1.71	1.39	1.33	1.50
78	1.69	1.38	1.29	1.48
79	1.67	1.27	1.26	1.42
80	1.63	1.19	1.25	1.37

NOTES: THE VERY HIGH RATIO IN THE R.B.S. MAY BE ASSOCIATED WITH THE POOR RELATIVE PROFITABILITY ON TOTAL DEPOSITS DEMONSTRATED IN CHAPTER 3. THE APPARENT HIGHER PROFITABILITY OF THE CLYDESDALE BANK COMPARED WITH THE BANK OF SCOTLAND IS NOT EXPLAINED BY THESE RATIOS - IT WOULD BE EXPECTED THAT THE BANK OF SCOTLAND HAD ADVANTAGE, IN TERMS OF THE MODEL IN THIS CHAPTER.

TABLE 3.11

DEPOSIT ACCOUNTS — AVERAGE BALANCES WITH TIME

DATE	BALANCE	AT JAN 70 PRICES USING R.P.I.
	£	£
JUL 71	234.88	204.96
APR 72	231.94	194.09
SEP 72	230.17	187.28
MAY 73	239.34	182.15
SEP 73	243.03	180.96
MAR 74	275.05	189.30
MAY 74	289.70	190.09
MAR 75	321.59	182.62
MAY 75	323.17	169.64
SEP 75	349.09	175.42
MAR 76	348.52	163.39
MAY 76	358.43	163.07
MAY 77	366.13	142.24
MAY 78	385.63	139.12
MAY 79	439.18	143.62
MAY 80	545.15	146.23

TABLE 3.12

SCOTTISH BANKS

AVERAGE DEBIT & CREDIT VALUES IN PERSONAL CURRENT ACCOUNTS WITH TIME

	DEBIT	CREDIT
	£	£
74	270.13	220.15
75	235.90	241.47
76	250.78	254.44
77	267.54	274.05
78	295.40	316.64
79	321.71	315.93
80	358.24	321.89

DEBIT CLEARING MILLIONS OF ITEMS TABLE 3.13

YR	TO RBS	TO BofS	TO C.B.	RBS TO LONDON	RBS TO SCOTTISH CB	RBS TO SCOTTISH BofS	CB OUTCLEARING TO OTHER BANKS
70	22.6	21.4	16.0	7.2	3.2	4.2	
71	23.2	22.8	18.0	7.2	3.2	4.0	16.2
72	27.1	26.2	20.2	7.9	4.1	5.4	18.2
73	33.5	30.8	22.1	8.9	5.7	7.9	20.4
74	34.4	34.4	24.1	10.6	5.8	8.4	22.3
75	39.6	37.1	26.0	11.5	6.6	9.5	25.0
76	42.5	40.4	30.3	10.6	7.2	9.6	28.0
77	45.9	43.8	34.0	11.7	7.8	10.1	31.4
78	49.6	48.1	38.2	13.4	8.8	14.3	35.4
79	53.1	54.4	42.9	13.5	9.7	15.9	39.7
80	56.3	60.3	48.1	13.6	10.8	17.9	44.5
AVERAGE GROWTH P.A.	9.6%	10.9%	11.6%	6.6%	12.9%	15.6%	11.9%

TABLE 3.14

CREDIT CLEARING MILLIONS OF ITEMS

	RBS INCLEARING TO BRANCHES	RBS OUTCLEARING SCOTTISH	RBS OUTCLEARING OTHERS	To RBS FROM SCOTTISH	To RBS FROM OTHERS
71	7.2	1.3	2.9	1.4	4.9
72	7.7	1.4	3.0	1.5	5.9
73	7.8	1.5	3.7	1.5	6.1
74	8.1	1.4	4.0	1.6	6.2
75	8.4	1.5	4.3	1.8	6.6
76	9.3	1.8	4.7	2.1	7.2
77	9.5	1.9	4.9	2.2	7.5
78	9.8	2.0	4.9	2.2	7.7
79	10.6	2.1	5.4	2.4	8.3
80	11.4	2.1	5.8	2.7	8.6

	B of S OUTCLEARING FROM BRANCHES TO SCOTTISH	B of S OUTCLEARING FROM BRANCHES TO OTHERS	B of S OUTCLEARING FROM BRANCHES TO BRANCHES	CB INCLEARING TO BRANCHES	CB OUTCLEARING TO OTHER BANKS
71				1.9	5.4
72				2.0	5.7
73				2.2	6.1
74	0.8	4.2	2.8	2.5	6.5
75	0.9	4.6	2.9	2.7	7.0
76	1.0	5.3	3.3	2.9	7.5
77	1.1	5.4	3.4	3.1	8.1
78	1.2	5.5	3.6	3.3	8.6
79	1.8	6.8	3.5	3.5	9.0
80				3.7	9.6

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Chapter 4 Technology for Retail Banks

Chapters 2 and 3 have considered the background to banking in Scotland over the decade 1970 - 1980. These chapters have considered the following aspects:

- changes in bank structure,
- changes in bank services,
- changes in levels of profitability and
- changes in workload.

Attention has been drawn to the need for cost containment, and costs of services have been identified as being related to the production of the information required to provide the services.

Before assessing whether computerisation has been successful in cost containment, it must be asked whether computerisation is a suitable approach to cost containment.

Since costs are associated with information production, this chapter examines the technology available for information systems and outlines one major aspect of information systems in the Scottish Banks, - their communications networks. This leads on in Chapter 5 to a more detailed description of the mode of computerisation adopted by the Scottish Banks.

First in 4.1, the appropriateness of general computer technology is shown by considering the processes involved in customer accounting and money transmission.

4.1 A short history of Technology in the Scottish Banks

The operation of a bank customer account is basically simple - there is a debit or credit in the account, and another account is credited or debited. Were transactions only to involve the branch or another customer of the same branch, the operation would indeed be as simple as aligning two files in one machine, and keying the one figure. However, the effort of aligning the files is in fact the major part of this task, and the advantage of automation by small accounting machines is swamped by this effort.

Were all payments to be regular and predictable, the increased effort of alignment would be overcome in some cases by the volumes of work in the actual accounting. However, there would still be the vast majority of accounts where the daily update would include at most one item, and where the paired transaction would be random with respect to account. Add to this that the majority of any branch's transactions involve another branch and another bank, and the problem is seen to be of a different order of magnitude.

However, although most bank transactions are effectively unique, each account is very similar to every other. As a result, although the transactions, seen by the customer, are seldom computerised, the complete account, seen by the bank, and summarised in statement form for the customer, has been for a long time successfully computerised.

The problem was to identify the parties to a transaction and to adjust the appropriate files, where the appropriate files might be any out of thousands on record. This is a problem for a computer of large capacity, and was long ago recognised as such. Throughout the sixties the banks developed accounting systems on large mainframe computers which could do on the large scale what small accounting machines could do for the payroll office. The cheapest form of solution, given the cost, size, and availability of computers, was seen to be the centralisation, usually at head office, of all the accounting functions of the bank.(16)

At the same time Banks were aware of a related and greater problem - the question of cheque clearing, and the growing volumes of cheque traffic. This was for long an area involving intensive physical work in sorting and moving paper. Clearing Departments of the Banks were not slow in demanding a computer solution to their problem, and automation of cheque sorting was a prime reason for installation of computers.

Since the data on the cheques forms a major input to customer accounting, the twin systems of clearing and customer accounting naturally developed together, using mainframe computers at Head Office.(15)

The advent of computers therefore removed the posting of cheques to accounts from the branch to the Head Office, and changed the position of the accounting function from the branch to the Head Office.

At 1970 only a proportion of bank branches were computerised. The mergers which produced the Royal Bank of Scotland, and the Bank of Scotland each slowed down, for a time, the increase in branch computerisation, because of the necessity to alter branch accounting systems in order to make them conform to one another. By Decimalisation Day in February 1971 only the larger branches had had their customer accounts computerised, and data transfer tended to be by means of paper tape - an unwieldy and unreliable method.

By that time Magnetic Ink Character Recognition (M.I.C.R.) had been adopted by the major banks as the basis for automation to assist cheque clearing.

Where branch accounting was already centralised, the captured data could be input directly to the system without manual interference by the branch. Since accounting was a major Branch task, the removal of accounting to centre should have decreased the requirement for Branch staff for that function (although not necessarily reducing total bank staff). In addition, the removal of any manual component of the system was considered by Bankers to be a step in the direction not only of cost containment but of accuracy. Accuracy has traditionally been seen by Bankers as highly important, and a major aspect of it will be considered in detail in Chapter 8. (see also Appendix H).

The number of cheques used by customers was increasing to the extent that the Clearing Banks of Great Britain set up a company called Banks Automated Clearing Service (B.A.C.S.) which began to make an impact on bank accounting in 1972. The main mode of operation of this company was to process magnetic files produced by users of the Direct Debit System,(13) which was designed as an electronic alternative to regular cheques. Naturally this works best with a computerised bank system, and further promoted the development of computerised branch accounting.

At about the same time, major developments in telecommunications[1] heralded the on-line age, and back-office terminals became standard in some banks within a short space of time. The associated computer systems were not always as advanced as the technology could have permitted because of limitations on systems development staff. In fact, throughout the seventies, all three banks in Scotland were concerned more with utilising technological potential, rather than searching for further advances.

'On-line' was not necessarily the only approach to computerisation, as witnessed by the decision of the Clydesdale Bank to set up Proof Centres instead.[12] At these centres the transactions of a number of branches were checked by automatic proof machines, and data captured on paper tape for computerised accounting.

It should be noted that although many Scottish bank branches were on-line from around 1973, the facilities available to the branch direct from the computer were for many years severely restricted. Considerable manual interference was till very recently required by any branch. Up-to-date customer account information could be obtained only with reference to a print-out delivered in the morning bag from head-office, with any in-branch adjustments made on a manual basis. "Real-time" accounting is, at 1980, not yet with us.

Over the ten years of the seventies, the three Scottish banks, more or less in parallel built up a basic batch branch accounting system.

The Counter, as the interface between the bank and its customers is generally known, has also seen computerisation.[2] Off-line cash issuing machines were introduced by the Scottish Banks in the late sixties but were not considered successful.[25] Money-changing machines for use by bank tellers (counter staff) have been experimented with in England, but have not found favour in Scotland. However, Cash Issuing Terminals, for use inside and outside bank branches are the focus for considerable investment at the present time, when teleprocessing networks are being reviewed because of the age of equipment. In addition, Teller Terminals have already been adopted by the Royal Bank of Scotland and the Clydesdale Bank.[5]

Figures on the cost-effectiveness of CIT's are not available. Nor were any full analyses done by any of the Scottish Banks before their decisions to use CIT's. This in fact reflects the importance of CIT's in marketing of bank services, these machines being seen as competitively necessary, and as an alternative to longer opening hours. The marketing of services has already been commented on as influencing the direction of computerisation, and it must always be borne in mind that computers exist in the Banks as part of an overall system, not only influencing but being influenced.

Bank systems have traditionally been paper based, and many of the systems currently run by bank computers have apparently an associated proliferation of paper. Typical is the situation of the cheque in the current account. This is written on paper, received by the payee, who hands it to a bank teller along with a paper pay-in slip. If cash is paid out, the teller notes this on a paper cash pad (currently being supplanted by teller terminals). The cheque itself is passed through the clearing, one of a bundle attached to a paper add-list of cheque amounts. When sorted it returns to the account holding branch, attached again to a paper print-out of sorted cheques. Ultimately it returns to the payer, folded in his paper statement.

Although this research considers the cheque very closely, it must at this point be stated that on the whole, the Banks cannot be greatly faulted for their use of paper. Paper is intrinsically an excellent medium for human communication of data. Its problem (or the problem of the machines) is that it is not machine readable. Given that paper is useful, the accuracy criterion, valued by all banks and by their customers, demands that copying be kept to a minimum. In the case of accounting, the original form containing the information should, if possible, be the actual input document to the processing system, be this manual or computerised.

The Banks have gone a long way in this respect, in that for virtually every operation the document presented by or filled in by the customer is used as the keying document. The main exception is the form filled in by a customer wishing to open an account, where there is a separate keying document filled in by the branch.

This document contains some additional fields, mainly for Bank of England Statistical purposes - and one extra field, which is thought might give offence if shown to the customer. This is the "Short Name" which is left to the invention of the branch to ease operating problems. For example, a community containing one hundred individuals, fifty of whom are called Donald McDonald, may well be numbered in their bank short names.

Considerable advances have been made in the past ten years, particularly in reduction of computer size, and in telecommunications.[6] Both have been seized on and used successfully in the non-clearing areas of banking, but current approaches promise no great hopes against the paper mountain. This will be a major consideration of this thesis.

The computers installed by banks in the 1960's were large, slow machines, with very limited capacity. Input was by card and paper tape. Central processor memory restrictions required efficient programs, which gave rise to ingenious monolithic sets of instructions. Systems were not, in the modern sense, integrated, one seldom impinging on another either in data content or process method.[14]

However, twenty years of technological progress in this rapidly advancing area has meant fundamental changes in hardware and software alike. Bankers recall with horrified humour the days when engineers went over a computer tapping all the valves with a hammer, to turn intermittent faults into permanent ones that they could then identify and correct. There was nothing unusual about the total system being down.

Today the system being "down" can mean a major problem in the on-line real-time environment of banking. Not satisfied with the built-in multiple redundancy of today's technology, banks' system configurations demonstrate considerable duplication in an effort to minimize the possibility of total system failure.

Changes in electronic components have been accompanied by increases in core memory capacity by many orders of magnitude, with a reduction in computer volume. There have also been vast increases in the speed at which instructions are carried out. The mode of data entry has also changed, with direct access to disc storage. As a result of the changes the emphasis is no longer on program efficiency, but on integrability of systems, with ease of maintenance and development. New applications exclusively use the modern modular programming.

However, in spite of regular hardware changes, a number of older systems are still used in the Banks - particularly those systems designed for accounting in the early 70's. These are regarded as a major nuisance in systems departments of all the Banks when changes are required in their suites. Gradually they are being weeded out as necessity dictates or opportunity allows a system rewrite.

In recent years, computer companies have developed high level languages for greatly simplified program writing, but while these improve efficiency, they do not remove the central problems from Banks' systems analysts and programmers. Machines and capacity have greatly improved, but system design, writing and implementation are, if anything, even more major tasks now than in the early days of computerisation.

This is partly due to the fact that it was the easy-to-write systems which were written first, and the more difficult problems remain. Also, the demand for integrated systems greatly increases the complexity of systems design.

From this short history it can be seen that Bankers realised at an early stage that computers offered a viable alternative to manual bank operations, and could form a useful part of their overall Information System.

Particular equipment for the various aspects of information systems is now described. (In 4.2 the subsections are in the order of the components of an ideal information system as set out in section 3.1).

4.2 Information Technology

The capability of modern computer equipment in Retail Banking can be considered with reference to the attributes of an information system set out in Chapter 3. In this respect it must be noted that, although the objective in both manual and machine systems is information production, the philosophy behind system design is dependent on the means of production. Human systems are characterised by the physical representation of the work-base - in Banking, the paper vouchers and ledgers. Data is explicitly available on human-readable media, usually paper, is manipulated by clerical staff, moved from one work space to another by manual personnel, who all, with their work, occupy space, and who proceed through their operations in finite and variable time units. Computer systems are characterised by an electronic representation of the work-base. Data is implicit in electronic code, which is machine readable. It is electronically manipulated, in infinitesimal time units, with all operations done in the same processors. Human systems are characterised by on-going corrective adjustment, while computer systems require virtually total de-bugging before implementation.

In considering the use and capability of computers in Banking, it must therefore be borne in mind that current Bank information systems use as the base of data cheque and credit vouchers, which being paper, are alien to computer systems. In a computer-based system, paper can be used as the carrier for input, and for output, but cannot be used in the computer itself as the work-base on which operations are carried out. Thus, automation cannot be an integral part of the processing in a computer-based information system. Thus, the use of automation for voucher sorting by Banks at the present time demonstrates that they use computer equipment to assist an essentially manual information system.

This section considers the equipment available for the various sub-systems of an information system.

4.2.1 Data collection : input and transmission

A number of computer peripherals have been developed for data collection in Banking, the earliest being the MICR reader for uplifting pre-encoded and subsequently added accounting data from cheques.

These machines can be regarded as terminals that can operate on line to the computer. However, they have intelligence in their own right, to the extent that software within the reader-sorter equipment can enable cheques to be sorted after reading.

Non-intelligent terminals for back office use were also an early component of data collection technology. The IBM 3980 range was extensively installed in the Royal Bank and the Bank of Scotland in the early seventies, replacing paper-tape punching machinery.

Intelligent terminals containing sophisticated software for calculation and validation have been installed in recent years as cash-issuing terminals, and teller terminals, such as in the IBM 3600 series, and the Clydesdale Bank CLANS system.

A considerable variety of other peripherals are available, using OCR and magnetic stripe technology, the latter featuring prominently in proposals for POINT-OF-SALE terminals to be installed in retail outlets to allow direct debiting of customer accounts to replace cheque usage.

In order to relay data from input points to the computer various data communications devices have been developed, initially using telephone and radio links. The special requirements for digital transmission have had spin-off in improved telephone technology. In order to use standard telephone lines and faster data lines MODEMS are used which translate data into transmissible code. Satellite communication is also available for transmission of large volumes of data. It is inappropriate for the Scottish scene, because of the small area involved (in relative terms), the weather, and the inadequate volumes of data for economic justification.

Recently, a new method of uplift from vouchers has been developed, called IMAGE PROCESSING. Strictly speaking, this is not data uplift, because the computer cannot interpret the codes that represent the vouchers. However, various considerations make it relevant to this study, although it will be more closely considered in relation to data storage.

4.2.2 Data Validation

There are a number of levels at which data transmitted to a computer is validated:

1. at the Byte level, using the parity bit
2. at the field level using check digits
3. at the record level, using a variety of systems algorithms.

The purpose of validation is to

a) confirm that data has been received correctly

b) confirm that all relevant data has been received

c) confirm that in any file data has not been duplicated.

A computer is such that, once a system is correct with proper data it cannot produce corrupt information. However, the correctness of a system is not guaranteed until all possible data conditions have been tested. Thus, severe testing is a feature of all systems implementation. In spite of this there are still risks of serious problems during commissioning due to unforeseen combinations of data.

Duplicate keying is a common component of data validation systems, this being a direct counterpart of the clerical checking procedures by duplicate work in pre-computer days.

Where computers can err, with correct data and correct systems is in faulty working of the electro-mechanical printers at the output stage.

4.2.3 Data Processing

Within the Banks the majority of processing is carried out in batch mode. Tapes are prepared during the day as business is conducted, using on-line facilities, and these form the basic files used for the evening's batch update. This mode of operation has existed since the first computer installations.

Real-time operation is carried out on a very limited scale in the cash-issuing terminal networks, but real-time accounting is not used, nor likely to be in the near future for ordinary retail Banking. Even point-of-sale installations are likely to be fed into tapes which are used in batch updating.

Database technology is a recent innovation in the Scottish Banks, and once again is not used in the retail banking context, but virtually confined to International and wholesale business. Database is not essential for real-time processing, being particularly suitable when file access is via a variety of different possible fields. In accounting, for example, entry need be via only the one field of sort-code-and-account-number, hence only requiring an indexed-sequential file. Database is not essential to an information system.

One of the most common programs in batch processing is a SORT, which is designed to re-order the raw data into a form suitable for actual updating of files. The speed of a SORT is determined (all other things being equal) by the amount of buffer space allocated to the SORT by the systems software. When records are relatively small the records themselves are sorted and change their location in the files. With large record sizes, the record itself is often not moved, and only its identification is sorted, so that the record can ultimately be retrieved by referring to an index. The amount of sorting required is determined by the size of the sort key. In cheque inclearing this is 14 digits, comprising the Branch identification and the account number. In outclearing, the sort key consists only of the 2 digit bank code number.

4.2.4 Data Storage

Most records used in computer systems are at some stage stored on magnetic tapes or magnetic disc. Normally, for all input and output two copies of all records are created, one serving as backup to cover failure or corruption. Of these two media, magnetic tape is best suited to sequential files, while disc is appropriate when random access is required. The magnetic stripe, common on sensitized terminal cards, is also used as the basis of mass storage systems for reduced-cost reliable long-term storage, with relatively fast retrieval time. It therefore combines the advantages of tape and disc for archival storage.

Computer output on microfiche (C.O.M.) is a common method of archival storage, as well as a basis for user-files which are accessed only occasionally. Microfiche frames are produced by displaying the data on video displays, and photographing it. A full fiche takes about two minutes to produce, and is suitable for permanent records. Microfiche is a direct descendant of microfilm which has been available for non-computer-based archival storage for a considerable number of years.

Magnetic storage is normally in the form of binary coding which reflects the alphanumeric contents of records. In Image Processing storage is of images of actual input vouchers using binary code. This development is seen to have considerable possibilities in Banking, because of the requirement for signature checking by paying Branches. Other applications have been proposed for the system, such as off-printing of cheque images onto customer statements.

However, the major use is seen as the possibility of making available to all users at the same time an exact copy of any voucher, without the necessity for the voucher itself moving physically from a place of storage.

An experiment in Image Processing in a Banking context was carried out by Burroughs in Midland Bank between late 1979 and early 1981. It is expected that there will be some publication of findings.

In this experiment, an additional module was inserted in a medium speed sorter which optically captured an image of each side of the cheque. These images were then translated into binary code, and stored on disc. By eliminating from the image the areas of the cheque that contained no printing or writing, the total image was stored in fewer bytes than would otherwise be necessary. Further selection of relevant areas of the voucher could again reduce the total storage required.

The image was displayed, black on white, on a video unit, with the capability of showing either side of the voucher, and of increasing image size, and also of displaying at the same time, an image of the authorised signature for the cheque.

The image processing system, by checking that there is appropriately sized content at certain positions on the cheque can confirm that required fields are present - for example, it can note the absence of a date, or signature. This is made considerably easier by having written fields in standard positions on the cheque, allowing machine-code identification of field positions.

The system showed considerable capabilities but also left a number of questions, notably on the extent to which the voucher image, as opposed to voucher content, is relevant to the Banking system.

4.2.5 Data Retrieval

The ability to reconstruct file records is essential to the audit trail in Banking, and adequate retrieval of data is therefore also an essential requirement. However, except when a complete re-run, using recent files, is carried out, such data is usually available only in archival storage, and not necessarily on magnetic media. Thus, such retrieval is the domain of software and operational guidelines, rather than of equipment. Adequate retrieval requires the creation of indexes which can be used reliably to locate the required data.

This is possible also within a machine when a disc position, for example, can be used to locate a record.

A common program, within the computer, to retrieve non-indexed data is a SEARCH. Each record is examined in turn for the presence of a particular item in a field, and all such records are gathered together as a file whose contents satisfy the appropriate condition.

Where related data exists on a number of files, retrieval of the whole group of records is only possible if there is a record of the manner in which the data on the files is related - in other words, if links exist between the data records. The most efficient link is one in which related data records have associated with them links that do not also relate to other sets of data. Such a link produces an unambiguous answer to the question of which data records are related.

4.2.6 Data output and Information Dispersal

Output from a process can be onto tape or disc for input to another system, or onto files which are stored as archives, or onto files used as the basis for printing or for COM. In addition, output can be transmitted direct to terminals at which printing or video display is used.

4.2.7 The above descriptions demonstrate that computer technology exists to cater for all aspects of information systems. This chapter now continues with a discussion of the heavy involvement of the Banks in information technology over and above what has already been shown in FIG 2.4.

4.3 Information Technology in the Scottish Banks

The phrase "Information Technology" today conjures up an image of Ceefax, and PRESTEL, so much so that few Bankers think of themselves as being concerned with information technology. (11) Yet, all three Scottish Banks have outlayed considerable investment in such equipment, the single most obvious example apart from data processing computers being in telecommunications networks. In the sixties, the equipment of the Banks used paper tape transmission, but the last decade has witnessed continued modernisation of these data collection systems.

At 1981 all three banks are in the process of a major update of their systems. The Bank of Scotland is replacing its branch terminal system with a new generation - the IBM 3600 series. The Royal Bank of Scotland is using this same series for a new network providing its cash-issuing terminals and teller terminals. These are operated by magnetic stripe cards.

The Clydesdale Bank has replaced all its Proof Centres by Remittance Centres, each of which services a number of branches. (At these centres NCR encoder/readers are on-line to NCR mini-computers on which tape records are prepared and transmitted to the central computers at Glasgow.)

In parallel with this system the Clydesdale Bank are installing teller terminals in all branches attached to a distributed computer network along with cash-issuing terminals in selected sites. Unlike the other two banks these networks are not IBM based, but use teller terminals provided by FORTRONIC, a Scottish company, and cash-issuing terminals provided by Chubb.

All three banks use Post Office leased lines of the S1 (normal telephone) and S3 (high-speed data) types.

Network usage has grown in line with the increase in the number of transactions taking place at branch counters and also, where static (see GLOSSARY) is keyed at terminals, with the growth in numbers of accounts and services, such as standing orders, which require static input.

4.3.1 Bank of Scotland Networks

In 1967 the Bank of Scotland decided to use back-office terminals to replace paper-tape transmission. The IBM 3980 system - which had been designed for the British market after pressure from Lloyds Bank - was chosen. Implementation of the network began in late 1968, when the first terminals were delivered. The terminal was purely a non-intelligent data entry/collection machine, attached to a concentrator which had limited intelligence capable of some editing of messages. The British Linen Bank was at that time investigating the use of Burroughs TC500 terminals, but after the merger the go-ahead was given to the 3980 system, although the British Linen Bank book-keeping system was used. The Bank of Scotland used, in addition to the 3980 system, the Assman system for, at the peak of network development, about 50 branches or sub-branches. At no time had there been the intention to bring all offices on-line, because of the combined cost of terminals and leased lines.

In 1977 the Bank of Scotland signed a contract to replace its back-office system with the IBM 3600 system, and bring the vast majority of branches on-line. This was first implemented in early 1980, some nine months later than had originally been planned, due both to supply delays, and system design difficulties. When the Royal Bank of Scotland launched its Cashline System, the Bank of Scotland decided to add cash-issuing terminals to its 3600 network.

The Bank of Scotland expects considerable improvements in throughput with the new system. On the 3980 there was found to be a loss in speed of about half, when remote positions were compared with local - 7 characters per second being printed, instead of 14. Since about 80% of the 3980 network was remote, replacement by the 3600 system, which is the same speed throughout, should prove advantageous. The 3610 printer is separate from the terminal, however, which could cause operator problems, as it is invisible during operation. In addition, it is friction fed. This can mean that faults can develop in which lines are run together or overprinted. In both systems the terminal print-out constitutes the branch Journal, although the complete record is also available from computer files.

The 3600 is a non-intelligent terminal, but there is a six-character memory within the keyboard. The Controller is, however, capable of storing data when onward transmission is not possible.

The Bank of Scotland intends to have the 3600 back-office network completely operational by late 1981.

4.3.2 Royal Bank of Scotland Network

1) THE IBM 3980 BACK-OFFICE TERMINAL NETWORK

The decision was taken in the late sixties to bring all branches of the Royal Bank on-line for centralised accounting of deposit, current and other accounts. Installation of the system was complete by mid 1973. At 1981 the system is still in use, with the original terminals still at many locations. The 3980 terminal is now obsolete, and replacements for worn-out terminals are obtained second-hand from other 3980 users such as Lloyds Bank.

The 3980 system consists of terminals with sprocket-fed printer paper, attached by S1 speed lines to concentrators which package together messages from a number of terminals and, when polled by the central computer, pass these on to the computer centre. Sixteen terminals can be attached to a concentrator at local or remote locations. IBM modems are used to interface with the leased lines attaching the concentrator to the centre, but where breakdown causes a back-up line to be employed, Post Office modems are used. Concentrators are switched off outside normal office hours. For English branches, which have different bank holidays, separate concentrators are used.

2) THE IBM 3600 CASHLINE AND TELLER TERMINAL NETWORK

The decision was taken in the mid seventies to introduce a cash-issuing terminal system, and the IBM 3600 system was chosen. Later, the decision was extended to implement the 3600 teller terminal system on the same network. It is expected that this system will be fully operational by late 82 or early 83.

The 3600 system uses 3601 controllers, which are micro-computers operated by programmed diskette, and work continuously. They can accept fewer attached terminals than the 3980 concentrator, but have considerable advantages in memory storage, both for incoming and outgoing messages. Keying can continue in situations where line failure, or central computer failure would cause the 3980 system to fail. The 3600 system and the 3980 system are incompatible.

With continuous operation of controllers, no special arrangements are required for bank holiday cover in different branches.

Case modems are normally used, but Post Office modems are required when back-up lines are involved.

Where no remote lines are attached to a controller (as in large Edinburgh or Glasgow offices) a cheaper controller - the 3600-5995 is used.

4.3.3 Clydesdale Bank Network

The network system of the Clydesdale Bank is totally unlike the systems in the other two banks, although there are superficial resemblances - the system supports cash-issuing terminals (like those in both other banks) and teller terminals (like the Royal Bank of Scotland 3600 system).

Unlike the other two banks - where the networks link concentrators or controllers direct to the central computer - the Clydesdale Bank uses a system of distributed processing, carried out by 18 VARIAN mini-computers which operate continuously without operator supervision.

This demonstrates a difference in outlook in the Clydesdale Bank which goes back to the earliest decision to computerise. Then, instead of choosing Branch input, the Proof Centres were set up, in order to bring under one roof the routine back-office work of a number of small branches, and so achieve economies of scale. These centres were first used in 1965 and only finally passed from the scene in late 1980. During 1980 the Clydesdale Bank was still receiving some computer input on paper tape.

The decreasing real costs of computer equipment during the seventies enhanced the decision to equip all branches with teller terminals. The bank chose FORTRONIC of Fife to develop a suitable terminal to be operated by magnetic stripe card. The specifications were for a terminal containing:-

(1) an operator keyboard

(2) a visual display

(3) a printer (using till roll paper - 16 characters wide)

(4) a magnetic stripe card reader

(5) a communications interface

(6) a customer keyboard

The terminal produced is intelligent - it contains micro-processor components - and is able, among other operations, to balance transactions before capturing them - i.e. before they are put onto magnetic media at the computer.

These terminals are attached to V77-600 computers, which contain a data communications multiplexer able to support up to 64 lines (each of which can have up to 16 terminals on it). Transactions from branches are stored on disc.

The local Varian contains memory space allocated to keeping records of cash items of a teller, so that using the terminal, the teller need no longer write up manual cash pads. Summaries and totals can be obtained by the teller on request.

The checked and edited data is transmitted from the local Varian to the Central Varian, which prepares all data for final entry to the mainframe computers for accounting overnight. This edited data is matched with details of transactions obtained from the Remittance Centre to which the branch has meanwhile sent its remittance items. The Computer Centre then produces a microfiche journal for each branch, on which are listed not only the credit and debit amounts in each transaction, but also the serial number, sort code number and account number of any cheques remitted.

4.3.4 Back-up for Failure

When designing any computer system care must be taken to cover the contingency of system failure due to component failure, and communications networks are no exception.

A primary cause for concern in communications is the reliability of data links. Research carried out in 1977 gave the following results:-

Equipment	Percentage failure per month
S1 lines	0.5%
S3 lines	2.25%
IBM 3980 Terminal	3%
IBM 3980 Concentrator	7.5%

Banks are more concerned with getting the system operational again when it does fail rather than with collecting statistics on failure: at 1981 however, it is estimated by one network control manager that this experience continues.

These statistics are not to be interpreted as meaning that high-speed lines are intrinsically less reliable than medium speed lines. S3 lines normally cover much longer distances, and can have several spurs.

When failure occurs, the branch dials up a normal Post Office telephone line and uses this for transmission to Centre. Action for other types of failure depends on the system involved.

IBM 3980 and 3600 Systems

Terminal Failure - For back-office work the terminal at the nearest branch can be used instead, with appropriate identification codes so that the work of the two branches does not get mixed.

Concentrator/Controller Failure - additional concentrators and controllers are available at the computer centre, and can be reached by the stand-by telephone line. In the case of concentrators, the terminal is informed of the last data received, and keying must restart at that point.

IBM 3600 System

Printer failure - The diskette in the controller will store keyed data until the printer is operational, at which time printing takes place. In the event of prolonged down-time printing can be carried out at a nearby branch, or at head office.

Central computer failure - the diskette will store data until the central computer is ready to accept data.

Terminal failure - (teller terminals) - with appropriate identification, a teller can use an adjacent terminal, and cash pad data etc. will not be mixed.

'CLANS' System

Terminal failure - a spare terminal is kept at each branch, and can be plugged in when required.

Local Varian Failure - Local Varians are installed in pairs at the local centres, and on failure, lines are automatically switched to the adjacent Varian.

Central Varian failure - the arrangement is the same.

All Systems

Central computer Failure - All the banks have at least two computers capable of carrying out the daily accounting work, as well as the continuous operation of their real-time systems. On failure, lines are switched from the failed computer to the back-up where processing continues. Files are kept and prepared in duplicate, and stored separately.

Actual costs of system failure have not been made available to the author. These costs consist not only of the cost of recovery from failure, but also the immeasurable cost of customer dissatisfaction. This latter cost becomes more important as customers become more aware of the presence of equipment, such as teller and cash-issuing terminals.

4.3.5 Comment

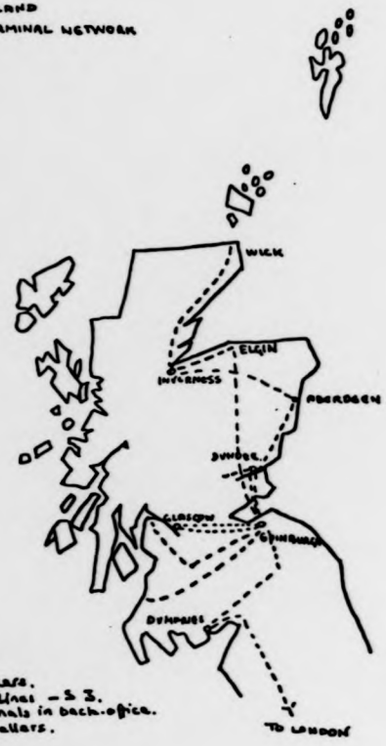
It is therefore demonstrated that the three Scottish Banks have installed sophisticated equipment as part of their total information systems.

From the above sections, a number of conclusions can be reached:

* Computers are suitable for carrying out bank operations.
* Computer equipment exists which is suitable for each aspect of information systems.
* The Scottish Banks do use information technology.
* Computer technology has been used for in-bank data collection, and for data processing.
* Computer systems of the Banks have extensive provision to cover the contingency of system failure.

The following chapter describes how this equipment is being used in the Banks to assist their production of information. This use centres on customer accounting and clearings.

BANK OF SCOTLAND
IBM 3600 TERMINAL NETWORK



47 Controllers.
14 Main Lines - 3 3.
451 Terminals in back-office.
91 Autotellers.

FIG 4. 1

FIG

IBM 3600 NETWORK PLAN

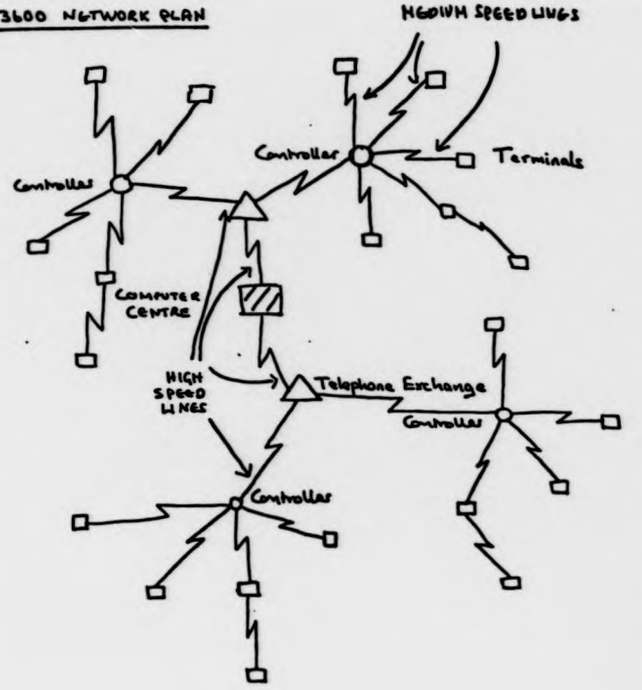


FIG 4. 2

ROYAL BANK OF SCOTLAND
IBM 3600 TERMINAL NETWORK

AT FEBRUARY 1981
24 MAIN LINES - 53
70 CONTROLLERS
UP TO 12 WORKSTATIONS PER CONTROLLER.
(CASHLINE TERMINAL OR TELLER TERMINAL)
UP TO 4 CASHLINE TERMINALS PER CONTROLLER.
1,000 TELLER TERMINALS, 136 CASHLINE TERMINALS.

FINAL NETWORK TO HAVE:
34 MAIN LINES - 53
OVER 200 REMOTE LOCATIONS.

FIG 4.3

ROYAL BANK OF SCOTLAND
IBM 3980 BACK-OFFICE TERMINAL NETWORK.

20 MAIN LINES - 53
48 CONCENTRATORS
600 TERMINALS - MAXIMUM IS 100 CONCENTRATOR.
600 51 LINES.

FIG 4.4

THE CLYDESDALE BANK
'CLANS' NETWORK
(CLYDESDALE BANK AUTOMATED
NETWORK SYSTEM.

VARIAN COMPUTER CENTRES.

GLASGOW - BRUNSWICK ST.
- LAWNDOR ST.
- CATHEDRAL ST.
EDINBURGH.
IRVING.
DUNDEE
ABERDEEN
ELGIN

1500 TELLER TERMINALS.

LONDON ATTACHED BY 3-2 LINE TO DUNDEE.

FIG 4 5

'CLANS' NETWORK PLAN

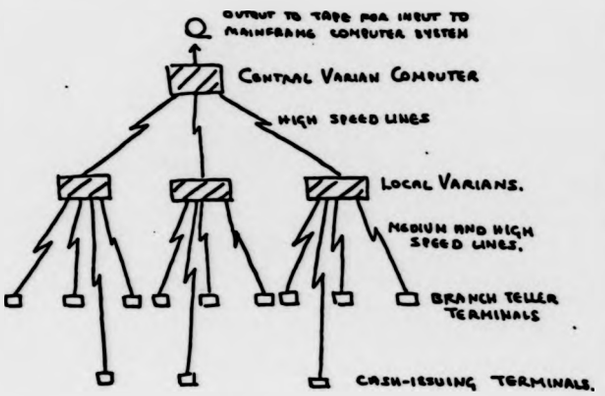
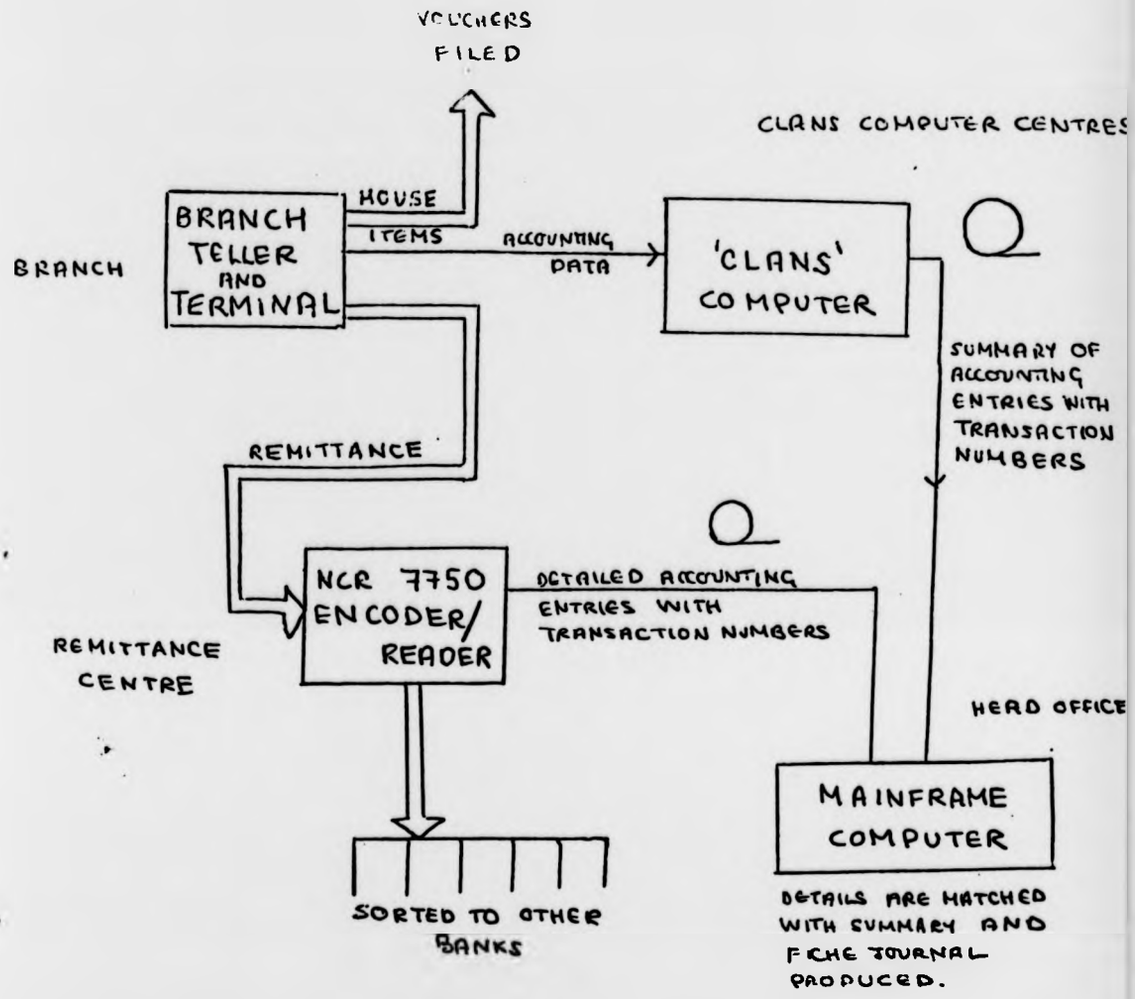


FIG 4.6



CLYDESDALE BANK 'CLANS' SYSTEM. FIG 4.7

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Chapter 5 : Customer Accounting and Clearings

This chapter continues examining the question of the past mode of computerisation of the Scottish Banks.

When faced with the possibility of computerising, various choices are open to systems designers: the computer can be used as the central element in a system and a computer-based system set up, or the computer can be used to assist an essentially manual system, using automation (see Glossary). Within both these modes further choices are also available - for example, whether processing should be in batch mode with this on- or off-line or real-time.

In order to examine which, or what mix, of these constitutes the past mode of computerisation in the three Banks, the principal features of their accounting and clearing systems are set out below.

As already stated in earlier chapters, these two systems dominate computer usage in the three Banks.

This chapter results from a detailed comparison of the systems of the three Banks, and consideration of their common problems.

5.1 The Nature of Customer Accounting

The retail customer is the cause of most computer usage in the Banks. At 1977 one bank measured that over 80% of its computing capacity was directed to retail banking, the remainder being shared between special applications such as overseas business and customer services.

The three Scottish Banks provide virtually the same accounting service to customers. In all three it is provided through the branch system. In this system a customer is deemed to have an account with a branch as opposed to having an account with the bank.

Routine decisions are taken at branches, although computer output may give warning information of irregularities. It is the responsibility of a branch to pay or refuse payment of a non-guaranteed cheque, if an account is not in credit; no computer system assumes such responsibility.

In bank information systems a computer can be thought of as a tool which carries out processes which previously were performed manually, and in the event of total system failure could still be performed manually. A lot of the work is in fact still carried out in an essentially manual way. It has already been stated that the Banks' information systems are merely computer-assisted, and not computer based, and this chapter will serve to demonstrate this.

This section considers accounting as a process with input and output (see Fig. 5.1.). Comparisons of the fine detail of the Banks' accounting systems are not done, as this is not relevant to the overall picture. However, sufficient detail is examined to establish the amount of data available to systems, and the information produced using it.

5.1.1 Customer Accounting Input : Static

The permanent details concerning an account are referred to as STATIC. These details must be obtained from a customer before an account can be set up. The branch obtains the following information:

a) Account type required - personal or business. If business, the class of business and whether a group member.

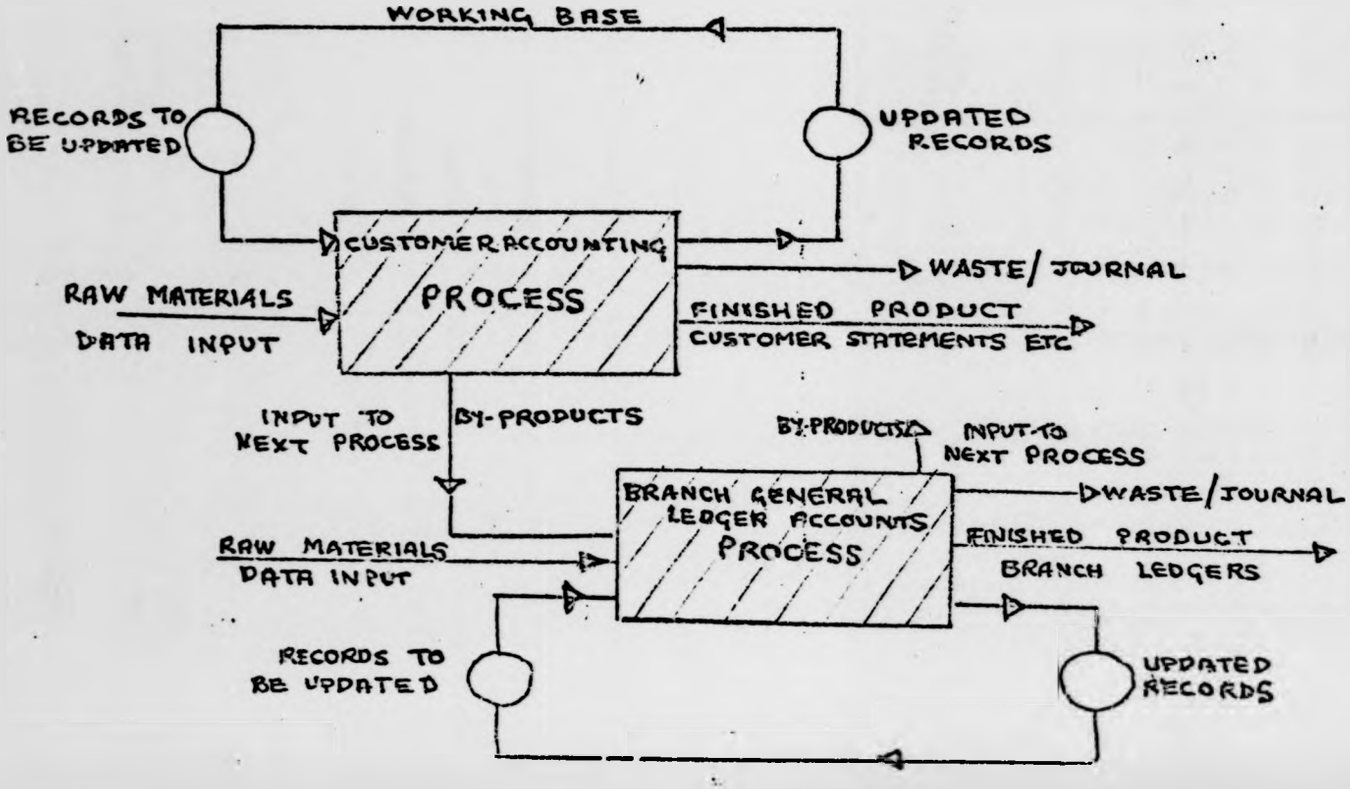
b) The mode of operation.

Current Account

Budget Account

Deposit Account etc.

DATA PROCESSING : CUSTOMER ACCOUNTS AND BRANCH GENERAL LEDGER ACCOUNTS FIG. 5.1



c) The correct name of the account - this can be, for example, a person's name plus account description, or a number of individuals etc.

d) The statement name - for mailing purposes this may differ from the account name.

e) The statement address.

f) The required statement frequency.

g) The amount of any deposit or advance made.

The branch also obtains specimen signatures, and instructions on how many signatures are required to operate an account. In addition, referees are usually requested, and references can be taken up.

When an account is being set up the manager or accountant will request directly or indirectly additional data, such as details of employer, annual salary, family circumstances - these details being considered important in judging the customer's suitability for advances, overdrafts etc. The customer will also be informed of other services available from the bank, and in suitable cases be given one or all of the following:

- cheque guarantee card
- 24-hour cash cards (RBS and CB) or vouchers (B of S)
- Cash Issuing Terminal card
- Introduction to Access (RBS and CB) or Barclaycard (B of S)

The above information is gathered manually and stored on cards at the branch for manual use.

5.1.1.1 Setting up the account

From these records, forms are prepared as computer input. These forms are in all cases marked out in boxes which indicate the fields required by the computer, and the maximum field lengths.

An account number is allocated. Each branch is informed of the range of numbers available to it and uses them as required, not duplicating numbers within branches. To this the computer will add the inter-bank Branch Sort Code number, which consists of 6 digits:

80-XXXX - Bank of Scotland

82-XXXX - Clydesdale Bank

83-XXXX - Royal Bank of Scotland

(It may be noted at this point that all three Banks act as clearing agents for local Trustee and other cheque issuing savings banks, which are identified by the same first two digits as the clearing agent).

A customer short name is allocated. By inter-bank agreement, this should be limited to 18 characters.

From the customer record various codes are identified and added to the input sheet in numeric form:-

the account type
Bank of England Classification of Advances
Bank of England A & D code
Bank of England overseas resident code
Whether a bad or doubtful debt
Whether a group member, and which group
Statement name and mailing address
Statement date and number of duplicates
Whether supplementary lists of credits or debits are required with statements
Overdraft limits and expiry dates
Whether a staff account

Individual banks add additional fields.

Codes are added for service charges and interest details. These are not required for deposit accounts where interest is paid at a standard rate and there are no service charges. Codes are also used to identify the account from which charges and interest are to be deducted, as this may differ from the account being set up.

5.1.1.2 Operating the account

There is now adequate information for an account to be made operational. The data is keyed at a terminal in the case of the Royal Bank of Scotland and the Bank of Scotland, and at centre in the case of the Clydesdale Bank. The account is then added to the branch's records at the next update.

Deposit account customers are given a pass-book by the branch. Interim part-encoded cheque books can be provided with current accounts, but branches and head office prefer, for clearing cost considerations, to wait for a fully-encoded cheque book before issuing cheques to a customer. Cards of all kinds, except very basic off-line cash-machine cards or vouchers, can only be provided after a production lead-time of about one week in most cases.

Computerised standing order systems, cheque guarantee card production, magnetic stripe card production, and cheque personalisation require additional static input.

Once an account has entered the computer files relevant to a branch, operations can be accepted on it.

5.1.2 Customer Accounting Input : Accounting data.

Accounting data comes from a number of sources:-

in-bank
- transactions at branches
- withdrawals of inter-account transfers at cash-issuing terminals*
- standing orders
- salaries to bank staff*

inter-bank
- paper clearing, credit and debit

BACS
- electronic funds transfer - credits and direct debits*

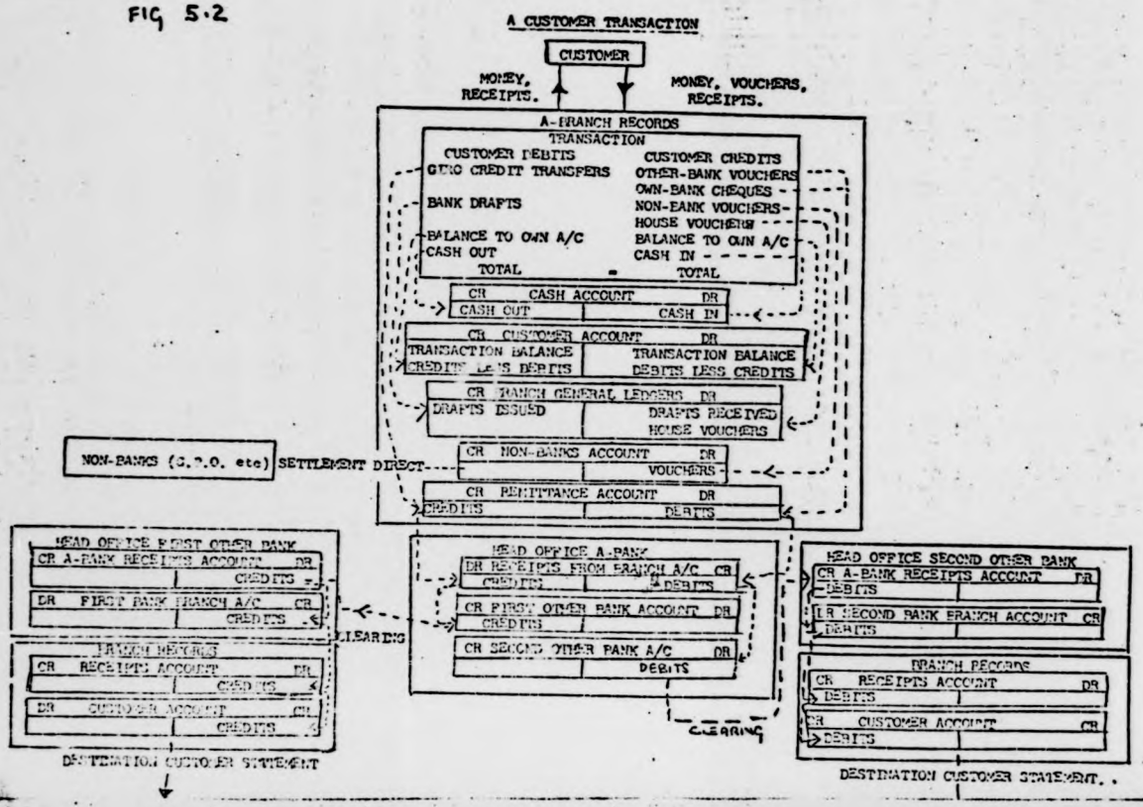
in-system
- bank charges, and interest

Should data fail to reach its account destination, it must be returned to source. Those items marked * are at their entry to the system fully known in magnetic form and in the case of a failure can readily be traced and correcting action taken. In each case the items concerned represent a one-to-one relation between credits and debits which is therefore fully and easily reversible. Standing orders, likewise, although in many cases still manually prepared, are fully known one-to-one transfers, and again can be reversed readily in the case of failure. Transactions at branches, and paper clearing are closely related. They will now be examined from the point of view of accounting data. Fig. 5.2 illustrates a transaction in simplified form.

5.1.2.1 The Transaction

A transaction can be thought of as taking place at a counter between a customer and a branch. It is an activity which generates credits and debits, each credit or debit constituting a movement in some account. It produces paper on which is accounting and other data. The simplest transaction consists of cash paid into or cash withdrawn from an in-branch deposit account. However, it can equally consist of cash and a number of vouchers paid-in coupled with credits to a number of accounts not necessarily in the same bank, plus cash withdrawn. The total of credits, plus the total of debits in every transaction balance to zero.

FIG 5.2


A CUSTOMER TRANSACTION
CUSTOMER
MONEY, RECEIPTS.
MONEY, VOUCHERS, RECEIPTS.
A-BRANCH RECORDS
TRANSACTION
CUSTOMER DEBITS
GIRO CREDIT TRANSFERS
BANK DRAFTS
BALANCE TO OWN A/C
CASH OUT
TOTAL
CUSTOMER CREDITS
OTHER-BANK VOUCHERS
OWN-BANK CHEQUES
NON-BANK VOUCHERS
HOUSE VOUCHERS
BALANCE TO OWN A/C
CASH IN
TOTAL
CR CASH ACCOUNT DR
CASH OUT
CASH IN
CR CUSTOMER ACCOUNT DR
TRANSACTION BALANCE
CREDITS LESS DEBITS
TRANSACTION BALANCE
DEBITS LESS CREDITS
CR BRANCH GENERAL LEDGERS DR
DRAFTS ISSUED
DRAFTS RECEIVED
HOUSE VOUCHERS
NON-BANKS (G.P.O. etc)
SETTLEMENT DIRECT
CR NON-BANKS ACCOUNT DR
VOUCHERS
CR REMITTANCE ACCOUNT DR
CREDITS
DEBITS
HEAD OFFICE FIRST OTHER BANK
CR A-BANK RECEIPTS ACCOUNT DR
CREDITS
DR FIRST BANK BRANCH A/C CR
CREDITS
CLEARING
BRANCH RECORDS
CR RECEIPTS ACCOUNT DR
CREDITS
DR CUSTOMER ACCOUNT CR
CREDITS
DESTINATION CUSTOMER STATEMENT
HEAD OFFICE A-BANK
DR RECEIPTS FROM BRANCH A/C CR
CREDITS
DEBITS
CR FIRST OTHER BANK ACCOUNT DR
CREDITS
CR SECOND OTHER BANK A/C DR
DEBITS
CLEARING
HEAD OFFICE SECOND OTHER BANK
CR A-BANK RECEIPTS ACCOUNT DR
DEBITS
DR SECOND BANK BRANCH ACCOUNT CR
DEBITS
BRANCH RECORDS
CR RECEIPTS ACCOUNT DR
DEBITS
CR CUSTOMER ACCOUNT CR
DEBITS
DESTINATION CUSTOMER STATEMENT.

Any combination of the following including one debit and one credit can produce a transaction:-

Credits	Debits
Paid-in cash	Cash withdrawn
Cheques	Credit transfers
Other vouchers (travellers cheques postal orders, bankers drafts etc.)	debit balance to own account (credit total less debit total)
credit balance to own account (debit total less credit total)	bank drafts

A transaction need not be carried out by a regular customer of the branch. Cheques can be drawn on any bank. Credits can be to any bank in the clearing system.

5.1.2.2 Vouchers and Cash

Cash can contain Scottish bank notes. As a point of principle one bank will not issue notes of another bank, and local note exchanges take place at appropriate intervals with differences settled by agent's claim forms drawn on the branch showing a deficit. Postal orders are also settled locally in cash.

Cheques are virtually all pre-encoded, in Magnetic Ink Character Recognition characters, known as MICR. Before issue to customers cheques are pre-encoded with serial number, bank sort code and account number. The amount is later encoded by the crossing bank - i.e. the bank to whose branch the cheque is paid in. The Bank of Scotland and the Clydesdale Bank encode centrally, while much of the amount encoding in the Royal Bank is done at its larger branches. MICR encoded data is in machine readable form, so all debit voucher accounting data can in theory enter the computer system.

Bank giro credits are rarely pre-encoded. Full reciprocal amount encoding of credit transfers will not be operational until April 1982.

Currently the Royal Bank of Scotland clears credits manually. The Bank of Scotland remits credits to other banks using an automated system. The Clydesdale Bank captures credit data for its own customers from credits received, and sorts the credits automatically to its own branches.

5.1.2.3 The Importance of the Transaction

Transactions are sources of accounting data, and form the basic working data of a branch. Formerly, each transaction was written up in a Journal, and the transaction components then separated by contra-type entries to the appropriate ledgers. The massive paper volumes which formed the branch Journal have been replaced by print-out of computer input, on paper or COM. In the Royal Bank and the Bank of Scotland transactions are input via terminals. In the Clydesdale Bank, the transaction is input both by the teller terminal and later at the Remittance Centre via reader-sorters.

In all three Banks a transaction can be identified by the values of the credit and debit components. These input values are verified in the first instance by zero-proofing. In this method, the principle involved is the fundamental idea of double-entry book-keeping - that the sum of all credits equals in magnitude the sum of all debits, and since they are opposite in sign, they balance to zero. The terminal systems of all three Banks employ this principle as a first check on transactions.

In the Royal Bank and the Bank of Scotland, vouchers are separated at the branch into credits and debits, and sent for encoding and clearing. At the Clydesdale Bank vouchers to be remitted are separated from in-branch items, a balancing note for house items is added, and they are sent bound together as a complete transaction, to a Remittance Centre. At the Remittance Centre, credits and debits together are encoded, and the total available MICR lines relevant to a transaction are captured and identified with the transaction. Credits and debits are only later separated for clearing purposes.

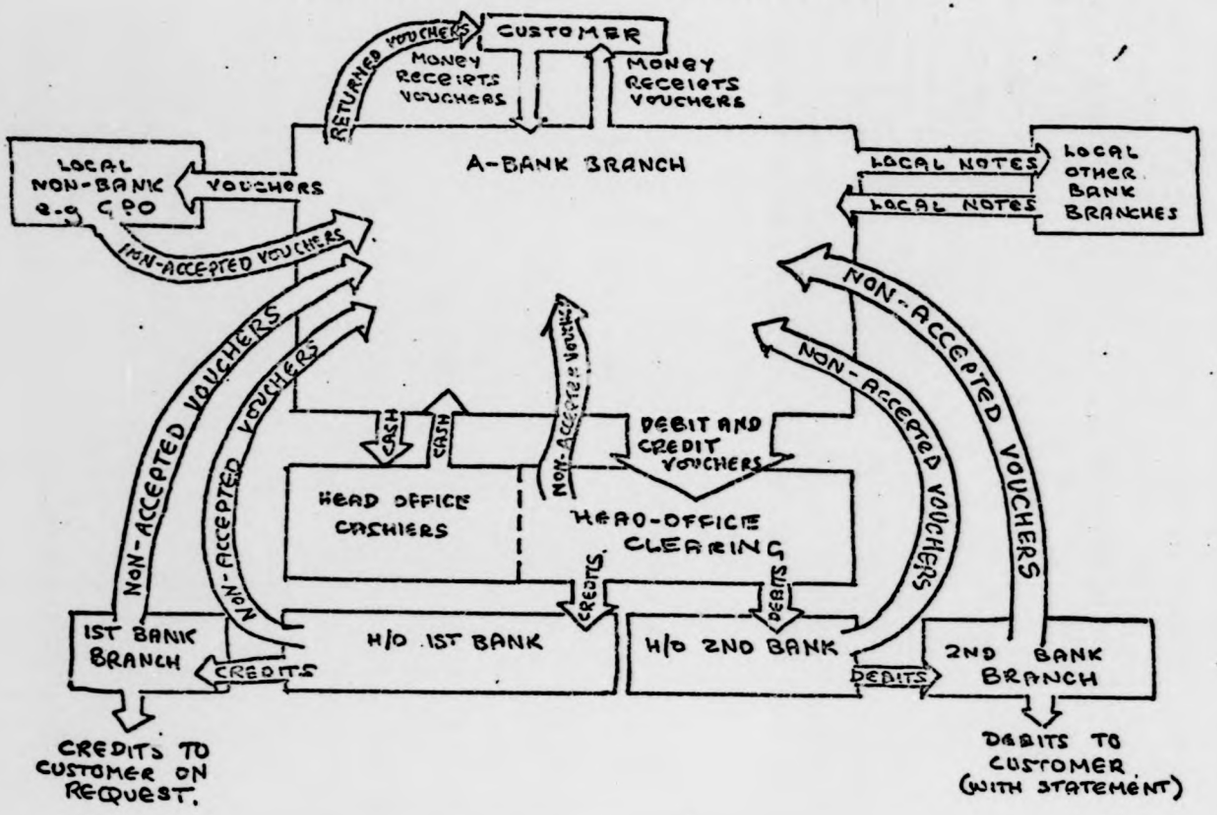
5.1.2.4 Transaction Failure

With any system it is not the rule but the exception which causes problems and therefore expense. In a complex transaction, failure occurs if any one of the component credits and debits fails to reach destination. A cheque or credit entering the clearing system may not reach destination because it physically becomes lost; in addition other errors may occur in the clearing process. These possibilities are examined more closely in Chapter 8.

A cheque may be prevented from passing through the clearing by being stopped at some stage in its progress due to a technicality. FIG 5.3 indicates the routes that such cheques will then take.

CUSTOMER TRANSACTION : PAPER FLOWS.

FIG 5.3



STRAIGHT LINES = NORMAL FLOWS.
CURVED LINES = ABNORMAL FLOWS.

On receipt by the crossing branch a cheque should be examined fully to identify any obvious technical errors, such as the following:-

NO BANK NAME

NO DATE OR INVALID DATE

POSTDATED

OUT OF DATE

NO PAYEE NAME

NO AMOUNT IN WORDS

NO AMOUNT IN FIGURES

AMOUNTS IN WORDS AND FIGURES DIFFER

NO ACCOUNT NAME

NO SIGNATURE

NO MICR BANK SORT CODE

If no technical error is discovered the crossing bank accepts the cheque and stamps it with a crossing stamp. The cheque can then be outcleared to the bank on which it is drawn. If no such bank can be found, Head Office returns the cheque to the branch.

On receipt by the inclearing bank the cheque is again examined and mis-sorted cheques are returned to the outclearing bank for re-direction. In addition, the inclearing bank can return a cheque because technical errors have been overlooked. Further technicalities can now prevent the further progress of the cheque:-

NO ACCOUNT NUMBER, OR INVALID ACCOUNT NUMBER

INVALID BRANCH SORT CODE

If passed through to the branch, either by automatic sorting or manual back-up, the branch can identify further irregularities:-

INCORRECT SIGNATURE(S)

SECOND SIGNATURE MISSING

CLOSED ACCOUNT

NON-EXISTENT ACCOUNT

INSUFFICIENT FUNDS (NON GUARANTEED CHEQUE)

*NOTE: These lists of irregularities are not exhaustive.

Similar technicalities can also prevent credits reaching destination.

5.1.2.5 Recovery from Transaction Failure

This is a significant problem in the Banks' accounting systems.

Except in the case when a non-forged cheque has been drawn on a bank but with no means of identifying the relevant branch and account (e.g. a non-encoded cheque is bound into a cheque book and later used by the customer), cheques failing on such technicalities are returned direct to the crossing branch which then has the responsibility of returning the failed cheque to the payee, and of cancelling any credits which were covered by the cheque. The locating of the person who lodged the cheque can be impossible if it was lodged by a casual customer with no account at the branch. Reversing the accounting entries is a clerical task. This is not computerised.

Every voucher is identifiable by sort-codes, and amount. However, in the Scottish Banks full use is not made of these codes. Identification of credits associated with a cheque requires a manual search through journals which contain little more than records of transaction amounts. In the case of a common amount (£5, £10 etc.) such a search will turn up a number of possible avenues of investigation in any one day's work.

This is because amounts and date only, such as basic journal entries consist of, are not unique to a single transaction. Thus the use of such entries alone for identifying the transaction to which an item belonged cannot in general be unambiguous, and therefore produces a requirement for more extensive checking once any transaction is proposed as the source of a voucher. This greatly reduces the efficiency of the system, as shown in the example:-

EXAMPLE:

	TRANSACTION DATE X JOURNAL ENTRY	
	CR	DR
Any credits of £10.00 on date X might have had this transaction as its source.	£10.00	5.00
		2.00
		3.00

Any debits of £2.00 £3.00 or £5.00 on date X might have had this transaction as its source

In addition, it is possible that the date of the voucher is mis-identified.

Thus for credit of £Y, or debit of £Z, all transactions involving such amounts must be examined to identify associated movements. This is time-wasting, when more full identification of transaction components is possible. The information content at the input stage of the current system is adequate to produce considerably more efficient data-links than currently are available in such outline Journals.

In this respect the Clydesdale Bank has a considerable advantage over the other two Banks in Scotland, because all journal entries include the full captured code line of any cheques involved in a transaction. Amounts of associated credits can thus be uniquely identified and reversed relatively speedily (though even these codes for credits are not in the Journal).

To identify the crossing branch the receiving bank reads the crossing stamp on the cheque. Crossing stamps are designed so that information is duplicated so that with only parts of the stamp legible the name and address of the crossing branch can be found. However, even so, with crossing stamps not always clear, identification is not always possible. On examination of 300 cancelled cheques the author found that on 15 the crossing stamp was totally undecipherable, and many of the others were almost illegible.

On the basis of this sample a branch can expect to have no knowledge of the crossing bank some 5% of the time. In such cases, however, the Head Office can - if the cheque was machine sorted - identify the batch where the cheque originated, and so identify the crossing bank.

Credits that are not accepted on technicalities are also returned to the crossing branch.

The data record of the passing of the cheque through clearing cannot be cancelled, and instead a series of contra entries is initiated and passed through the accounting system.

5.1.2.C Comment

The transaction is therefore the lynch-pin of customer accounting. It is therefore in the interests of all the banks to retain transaction details in as complete a form as possible, to ease tracing in event of transaction failure. Transaction numbers are allocated in all Banks, but their use so far is minimal. They could, if full transaction data were collected, be used as an index in a computer-based data-retrieval system for easing transaction reversal as well as for information reconstruction.

. There currently exists an IBM 5922 reader which is suitable for installation in branches, and, once credit-encoding has been standardised, could economically be added to the systems of both the Bank of Scotland and the Royal Bank of Scotland, to increase the information content of their Journals, by reading into the system total voucher identification data before vouchers are separated for clearing.(2)

This matter is examined further in Chapter 8.

5.1.3 Customer Accounting : System data

The remaining data required for accounting purposes consists of the various system parameters for charges and interest, and the historical data on the account already held on file. The former are input as required by computer operators, and the latter is held on magnetic files, and loaded as required during the processing stage.

5.1.4 Customer Accounting : Process

In all three Banks the basic and chief mode of data processing is a daily batch updating system on sequential account records. In outline, the accounting system is as follows:

- all data is validated and sorted.
- accounting data is merged.
- the accounts records are accessed, and each account is processed in turn as follows:-

1) all changes to STATIC are carried out.
2) accounting entries are posted and a new balance struck.
3) interest is calculated if on an interest date.
4) bank charges are calculated if on a charge date.
5) interest and charges are posted, and a new balance struck.
6) a statement is prepared if a "page" is full, or a statement due date reached.

- the updated account record is then output to file, and extract totals for branch accounting recorded.
- when all accounts for an individual branch have been updated, totals for the branch are calculated for posting to branch general ledger accounts.

This differs from the manual process in that in a manual system each item is dealt with separately and not first logically sorted.

All three Banks use a modified form of real-time processing with their cash-issuing terminals, but the full accounting system of none of the Banks is at present in a form suitable for real-time accounting. It is questionable whether there is any immediate demand for such a service.

5.1.5 Customer Accounting : Output

From the customer's point of view the basic output of an account keeping system is the statement of account and the cancelled cheques as in a manual system. Banks are prepared to issue statements on a number of frequencies. These are sent to the branch, where they are added to vouchers received to date. Where a particularly large number of credits or debits appears on specific days, the branch can request that a total figure enters the statement, and supplementary lists to explain the total are produced instead of statements. These supplementary lists are usually printed 3-up, and so use much less paper, and are less bulky, and faster to print.

In the branch, statements are checked against vouchers received (at least in theory) and any errors found corrected. Debit vouchers are sent with statements to all customers of the Scottish Banks. Credit vouchers can be requested by high-volume customers.

The customer, however, is not the only user of output. The bank branch manager is interested in the conduct of an account, and gleans much of his knowledge of customer credibility from a regular examination of outgoing statements and their associated vouchers.

In order to ensure the accuracy of records, to enhance service to customers, to trace failed transfers, and to maintain branch accounts as opposed to customer accounts, further output is prepared by all Banks, in one or more of the three forms - paper, COM or magnetic media.

Examples of statements from each of the three Banks are shown in FIG 5.4, 5 and 6. It can be seen that there is great similarity between the statements.

RBS STATEMENT (HALF ACTUAL SIZE)

FIG 5.4

Statement of Account

The Royal Bank of Scotland Limited
BRANCH NAME

Branch No	Account No	Page
83-XXXX	XXX XXX	3

MR & MRS JOE BLOGGS
15 ANY STREET
ANY TOWN
ANYWHERE
COUNTY

Title of Account
JOSEPH BLOGGS AND
MRS JOSEPHINE BLOGGS

Cheque No or Abbreviation	Particulars	Debited £	Credited £	19XX	Balance £
	BALANCE FORWARD			21DEC	87.58
022735		13.93		24DEC	73.65
			1356.61	27DEC	1420.26
S/O	BUDGET A/C	155.00		28DEC	
041799		201.70		28DEC	
041800		50.00		28DEC	1023.56
S/O	REL	25.00		31DEC	
INT TO	19 DEC-A/C XXX XXX	5.19		31DEC	
INT TO	19 DEC-A/C YYY YYY	13.06		31DEC	
041807		456.00		31DEC	574.29
				1JAN	
041809		50.00		2JAN	474.29
041797		137.67		4JAN	
041802		700.00		4JAN	
125757		22.50		4JAN	336.62OR
			648.25	7JAN	
026941		18.85		7JAN	
020944		9.40		7JAN	
041795		50.93		7JAN	
041810		50.00		7JAN	133.33
026943		26.63		8JAN	106.70
041812		18.32		9JAN	88.38
041806		34.56		10JAN	
041813		50.00		10JAN	3.82
CARD 2	CASHLINE 12JAN	49.00		14JAN	45.18CR
022944		9.20		15JAN	54.38CR
	CASH CARD	10.00		16JAN	
	CASH CARD	10.00		16JAN	
	CASH CARD	10.00		16JAN	
	CASH CARD	10.00		16JAN	
	CASH CARD	10.00		16JAN	
	CASH CARD	10.00		16JAN	
	CARRIED FORWARD				114.38CR

Abbreviations Used
ADV – Separate Advice
BGC – Bank Giro Credit
CHG – Charges
D.D – Direct Debit
DIV – Dividend received
INT – Interest
LST – List of items
S/O – Standing Order

Lists	Debit Vouchers	Total Debited £	Total Credited £	Balance £

DR Account Overdrawn

B of S STATEMENT (HALF ACTUAL SIZE) FIG 5.5

BANK OF SCOTLAND
BRANCH NAME
BRANCH POSTAL ADDRESS

STATEMENT OF CURRENT ACCOUNT

Account No. 00XXXXXX
Branch Code 80-XX-XX
Page No. 28

MR J BLOGGS & MRS J BLOGGS
15 ANY STREET
ANYTOWN
ANYWHERE
POSTCODE

Date	Description	Debits	Credits	Balance
30JAN YR	BROUGHT FORWARD			173.83
5FEB YR	124706	108-12		
	124709	10.00		5.71
12FEB YR	BANK GIRO CREDIT		43.06	48.77
14FEB YR	CHARGES TO 1 FEB	0.31		48.46
15FEB YR	BANK GIRO CREDIT		29.48	77.94
18FEB YR	124710	24.26		53.68
21FEB YR	124711	50.00		3.68
25FEB YR	BACS CREDIT PAYER NAME		152.36	156.04
26FEB YR	124712	1.65		154.39
29FEB YR	INTEREST TO 26 FEB	0.25		154.14

Statement Date	* No Voucher For This Item	Total Debits	Total Credits	"OR" - Overdrawn Account
29FEB YR	Number of Debit Vouchers 5	194.59	224.90	154.14

C.B. STATEMENT (HALF ACTUAL SIZE) FIG 5.6

C

DD

MR & MRS J BLOGGS
15 ANY STREET
ANYWHERE

C.

Sorting Code No 82-XX-XX
Account No XXXXXX
Statement No 2

MRS JOSEPHINE BLOGGS & MR JOE BLOGGS.
E OR S J & S

In Account with

Clydesdale Bank Limited

BRANCH POSTAL ADDRESS

Telephone No XXXX

Statement Issued on 8 DEC 19YR

Date		Description	Debits	Credits	Balance
7 NOV	19YR	Balance Forward			316.45 C
13 NOV		364183	4.60		311.85 C
17 NOV	DD	AUTOBANK DEBIT	49.00		262.85 C
20 NOV		364189	67.00		195.85 C
21 NOV		364187	67.64		128.21 C
25 NOV	TR	BACS CREDIT PAYER		263.84	392.05 C
27 NOV		364184	1.80		390.25 C
28 NOV		364185	23.96		366.29 C
2 DEC		364188	98.29		268.00 C
5 DEC		000001	28.07		239.93 C

Abbreviations: DD Direct Debit; DV Dividend; E or S Repayable to Either or the Survivor; J & S Jointly and Severally; SO Standing Order; TR Transfer; C Credit; D Debit

In addition to an extract of the static relating to an account the statement provides the following information either directly or indirectly:-

The statement date

The Balance Brought Forward

The date of each movement

The amount of each movement

The day-end balance at each date of movement

The cheque serial number or the cause of each movement.

The statement does not give:-

The cheque payee name

The source of non-BACS giro credits

whether cheques were guaranteed (with bank card number).

These deficiencies are considered further in section 5.4 and in Chapter 9.

Customers regularly request up-to-date information on their accounts. In order to provide this service, all three Banks produce microfiche reports for all branches, showing for each account, the name, balance, cleared balance, interest and charges to date. In addition, details of all postings to the account since the last statement are also shown.

For branch use, paper lists of general ledger totals are produced and lists of irregular accounts to be referred to the Manager.

All three banks inform branches daily of changes made to STATIC. Computer output is also used as a vehicle for information to Managers, such as base rate changes etc.

The chief output of the Accounting system, from the point of view of its on-going nature, is the set of magnetic files containing all the updated customer information. These are maintained safely in duplicate at the Computer Centre for input to the next update.

5.1.6 Shortcomings of the System

The Accounting Systems of the Banks are not in every respect the best suited to user needs.

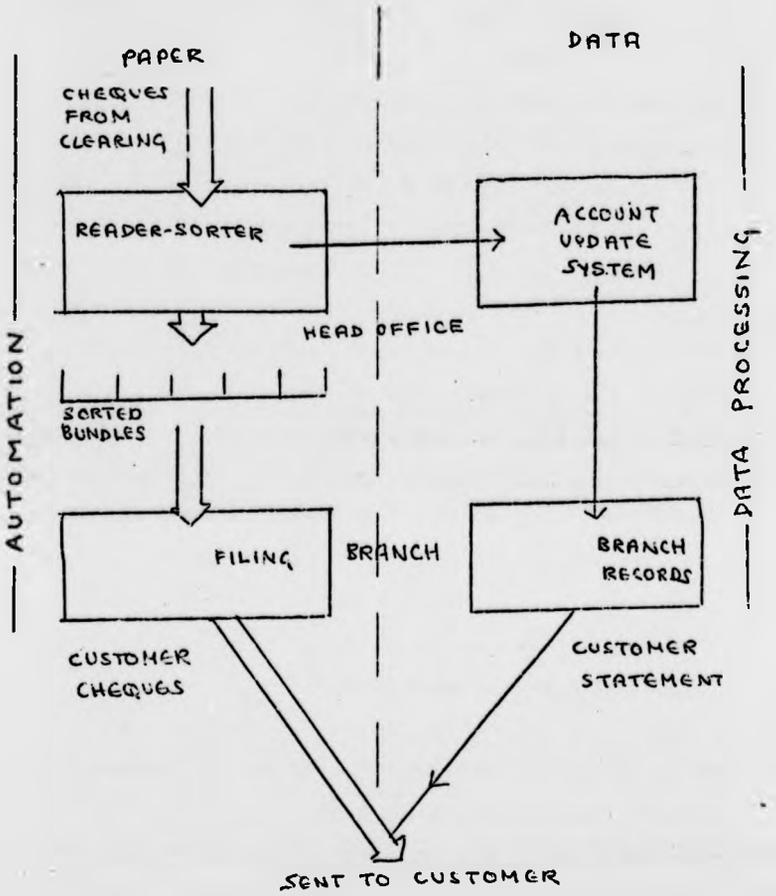
One obvious drawback is the difficulty involved in changing the branch at which an account is held. In all Banks, to do this, the account must be closed, and another opened, with the majority of the static data carried over.

For current accounts there is the additional problem that credit arrangements made with one branch manager will not automatically be continued in a different branch. These problems stem from the branch system of accounting. The numbering systems used in the Banks are but one of the problems to be overcome if the difficulties of account transfer are to be eliminated. (Account numbers are unique only within branches). The Banks have, over time, simplified customer procedures for transfer without making the fundamental changes in their systems which could make transfer automatic. Within Bank systems it is still necessary in such cases to close accounts and open new accounts for which the carried-over static must be set up again.

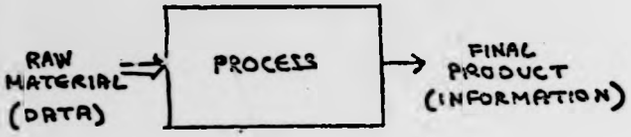
Another failing is the virtual absence within banking of the "account-to-account transfer" as offered, for example, by the National Giro Bank. In the simplest transfer in a Clearing bank it is necessary to debit one account and credit branch, then debit branch and credit another account. The third party must be brought in, thereby at least doubling the work involved in the transfer. This has evolved in banking from the variety of banks which might be party to a transfer between accounts, whereas in the monolithic National Giro Bank the bulk of transfers are between Giro accounts. However, the growth of multiple account holding both by companies and individuals suggests a changed balance in the Banks, and this, alongside the arrival of National Giro Bank, has led to the request for a one-voucher or one-keying account-to-account transfer. The Banks have responded through their cash-issuing terminal systems, with which, to a limited extent, this service is offered. It is possible in one keying sequence to take a single amount out of one account and have it transferred to one other account held at the same branch. It does not allow for more than one branch, or for a single debit combined with several credits or vice versa. Extension of this system could help to control the growth of both debit and credit clearings.

FIG 5·7

PAPER AND DATA FLOWS: CLEARING AND ACCOUNTING



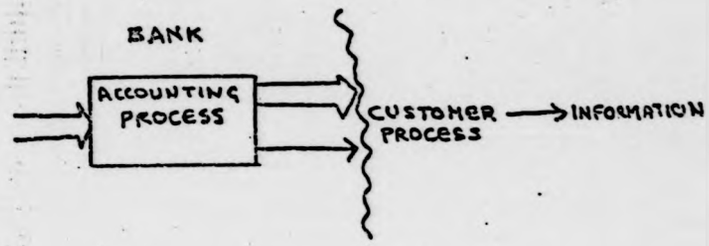
DATA PROCESSING



⇒ IMPLIES RAW DATA CARRIERS

→ ONLY INFORMATION

CUSTOMER ACCOUNTING



A "DO-IT-YOURSELF" ACCOUNTING KIT.

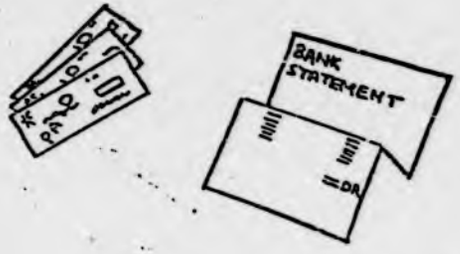


FIG. 5.8

5.2 : Clearings

Numerical accounting is carried out in the Banks on computer-based systems. However, the numbers alone are not enough to produce all the required information.

By far the greater number of account movements take place on current or chequing accounts using the Clearings. Clearings, originally designed for bank notes and cheques only, have been extended over time to cover all forms of money transmission.

Here the computer is used to control a machine which physically sorts the vouchers. The computerisation involves replacing a manual physical process with a machine physical process. Thus the mode of computerised paper clearings comes under the term AUTOMATION as defined for this thesis. During this process some data on cheques is uplifted and used as basic input to the accounting system. However, other data is not uplifted and the vouchers from the Clearings form the base of the major information system of retail banking, whose output is the package of customer statement and paid cheques.

5.2.1 Random Remittance

All three Banks are operating for cheques what is described as a Random Remittance System. The vast majority of cheque sorting has been removed from the branch which now remits items in random order. These cheques are then passed through automatic reader-sorter equipment, which separates them into those destined for other branches of the same bank, and those destined for other banks. Reader-sorters come in a variety of speeds, with fast-sorters being used for in-clearing (that is, the sorting of all cheques destined to branches of the sorting bank). Fast and medium-speed sorters are used in out-clearing, the Royal Bank and Bank of Scotland using fast sorters for their centralised random remittance system, and the Clydesdale Bank using medium speed sorters in its Remittance Centres.

5.2.2 Other aspects of Clearings

No branch sends to its head Office a cheque which is drawn on one of its own accounts. These are sorted manually, and appropriate entries to the central accounting records are made through terminals. (Many such non-transmitted items are cash-cheques, and all Banks are attempting to remove these from the system by the use of teller- and cash-issuing terminals).

Vouchers exchanged consist of the following:-

DEBITS Other bank notes
cheques
other vouchers - traveller's cheques
postal orders
banker's drafts etc.

CREDITS Manual standing orders
Credit transfer slips.

Bank notes and postal orders are cleared locally. Other vouchers can pass through the clearings, though not all do. The net effect is to move the vouchers to head office, and from there to the inclearing bank and branch, via inter-bank Clearings or exchanges of vouchers. How this is done is outlined in TABLE 5.1.

Direct treatment of vouchers can occur when a large amount of money is involved, or speed is requested by the customer. (Large amounts are not, however, always settled direct). In addition a considerable number (the actual numbers unknown) of credit vouchers are sent via first class post to the receiving branch for large corporate customers on a service basis agreed between the customer and the branch manager. Such vouchers are largely for monthly salary payments, and could in many cases be routed via BACS. The cost to the Banks of the service offered to these customers is not known.

In a steady-state condition[5], the net outclearings from a bank should equal the net inclearings. These are in fact found to be different with an apparent net paying-out of monies. The direct settlement of vouchers is one cause for this difference.

The value of items cleared also depends on the type of clearing. Credit outclearings to London, for example, contain very large numbers of small amounts to mail-order companies, while credit inclearings contain very large numbers of large salary payments. The difference is not as obvious in the case of cheques. Payments of cash into branch accounts are also not included in the Clearings figures, and these payments, from retailers, do represent substantial sums.

PROCESS	BANK		
	RBS	B of S	CB
LOCAL VOUCHERS (G.P.O. other bank notes etc.) EXTRACTED	AT BRANCH (1)	AT BRANCH (1)	AT BRANCH (1)
VOUCHERS SORTED INTO TYPES	AT BRANCH (2)	AT BRANCH (2)	AT REMITTANCE CENTRE AFTER DATA UPLIFT. (3)
VOUCHERS ADD-LISTED	AT BRANCH (3)	AT BRANCH (3)	AT REMITTANCE CENTRE DURING ENCODING (2)
VOUCHERS ENCODED	MOSTLY AT BRANCH (3) SOME AT HEAD OFFICE	AT HEAD OFFICE (4)	AT REMITTANCE CENTRE (2)
VOUCHERS SORTED TO BRANCHES & OTHER BANK DESTINATIONS	AT HEAD OFFICE (4)	AT HEAD OFFICE (5)	AT REMITTANCE CENTRE (4)
OUTCLEARING ADD-LISTING	AT HEAD OFFICE (5)	AT HEAD OFFICE (6)	AT REMITTANCE CENTRE (4)

NOTES: NUMERALS GIVE ORDER OF PROCESSES IN EACH BANK

TABLE 5.1

CLEARINGS: WHERE PROCESSES HAPPEN

5.3 Changes in Clearing with automation

Table 5.2 demonstrates the route taken by a cheque passing through interbank clearings. The first divergence from the non-automated route is at the branch where the first sort is now omitted. At Head Office or Remittance Centre the randomly ordered bundles are received, and after any necessary encoding an additional voucher, known as the Docket Control Voucher (D.C.V.) is added to the bundle. On this is encoded the bundle number and the total amount of the bundle. Encoding is done with MICR printers, which produce add-lists while encoding is being carried out. Being mainly mechanical or electro-mechanical these encoders are not trouble-free, and some consequences of this are examined in Chapter 8. Additional vouchers can also be added for system convenience. The bundle is then put into the reader-sorter as one unit, with the D.C.V. in front. The machine reads the code line on each cheque and sorts it into the correct pocket. Here arises another difference from manual clearing. Not all cheques are machine readable, and for a number of reasons a cheque may be rejected. The rate of rejection can be anything from 2% to 15% depending on the quality of the paper, of the encoding and of the machine. The DCV and rejected items are sent to the same position in the machine. The rejects are hand-sorted and add-listed and added to the machine sorted bundles after reconciliation with the original DCV total. Sorted items are removed and bundled with machine-produced add-lists, and physically transported to the agreed clearing point, where vouchers are passed over. Once again, this is identical to the non-automated clearings.

At the second bank new DCV's are produced and attached to the bundles, which are then fed through reader-sorters. Again there is the possibility of rejection, followed by manual sort and reconciliation of totals with the original add-list.

All Banks are aware of the disadvantages of not having a computer list of rejected items, and to remove this problem reject-re-entry systems are being developed. In a reject-re-entry system vouchers whose MICR codeline has not been read are processed again, so that the data on the codeline is slotted into the computer files at the correct place. This allows full computer listings of sorted vouchers, and also full machine sorting of vouchers (see Chapter 7 for further discussion).

TABLE 5.2

THE DEBIT CLEARING PROCESS

AUTOMATED		NON-AUTOMATED
CUSTOMER PASSES CHEQUE TO TELLER		CUSTOMER PASSES CHEQUE TO TELLER
TELLER SENDS CHEQUE TO BACK OFFICE		TELLER SENDS CHEQUE TO BACK OFFICE
BACK OFFICE ADD-LISTS ALL CHEQUES AND SENDS THEM TO CENTRE		BACK OFFICE SORTS CHEQUES BY BANK AND PREPARES ADD-LISTS
CHEQUES ARE AMOUNT ENCODED		
DOCKET CONTROL VOUCHERS (D.C.V.) ARE PREPARED FOR EACH BUNDLE		BUNDLES WITH ADD-LISTS ARE SENT TO CENTRE
BUNDLES WITH D.C.V.'s ARE PUT THROUGH READER-SORTER		BUNDLES ARE SORTED INTO PIGEON HOLES
DATA IS CAPTURED CHEQUES ARE SORTED BY BANK COMPUTER LISTINGS ARE ADDED TO SORTED BUNDLES		NEW BUNDLES IN PIGEON-HOLES ARE ADD-LISTED AND LISTS ADDED TO BUNDLES.
BUNDLES ARE SENT TO OTHER BANKS		BUNDLES ARE SENT TO OTHER BANKS
BUNDLES ARE RECEIVED FROM OTHER BANKS		BUNDLES ARE RECEIVED FROM OTHER BANKS. TOTALS ARE CHECKED
D.C.V.'s ARE PREPARED		
BUNDLES ARE PASSED THROUGH READER-SORTER DATA IS CAPTURED CHEQUES ARE:-		BUNDLES ARE HAND-SORTED TO BRANCH ORDER
SORTED	or REJECTED	
CHEQUES ARE PASSED THROUGH AGAIN FOR FINAL SORTS TO BRANCH	CHEQUES ARE HAND-SORTED TO BRANCH ORDER	NEW BUNDLES ARE SENT TO BRANCH
	.	BRANCH SORTS INTO ACCOUNT ORDER
CHEQUES ARE PASSED FOR SORT TO ACCOUNT	.	BRANCH READS DATA FROM CHEQUES AND INPUTS THIS TO CUSTOMER ACCOUNT LEDGER
CHEQUES ARE PASSED FOR SERIAL SORT	. (FURTHER STAGES AS FOR NON-AUTOMATED CASE)	
MACHINE LISTS ARE PREPARED		CHEQUES ARE FILED
ALL CHEQUES ARE SENT TO BRANCH BRANCH CHECKS BUNDLES AND LISTINGS BRANCH FILES CHEQUES IN CUSTOMER ORDER		
BRANCH SENDS CHEQUES WITH STATEMENT TO CUSTOMER		BRANCH SENDS CHEQUES WITH STATEMENT TO CUSTOMER

Each reader-sorter has a maximum number of pockets - usually less than 20. Thus it is not possible for a pocket to be unique to one branch. The first time bundles are passed through the machine some branches are grouped together. These groups are then passed through again as many times as is necessary to sort cheques to individual branches. Each such operation is called a PASS. At PASS 1 the machine operates an on-line mode and the code line is transmitted to the central computer. On subsequent passes the machine is off-line.

The final result is to produce bundles for each branch. At the same time the computer has sorted the captured data and produced lists for each branch. In theory these lists give exactly the individual codes and values in the bundles of cheques. In practice they do not, and this is considered in Chapter 8.

Branches with very large numbers of cheques will have cheques passed through the sorter yet again to arrange them into account number, and, for large customers, serial number sequence. Thus an individual cheque can pass through reader-sorters in excess of 10 times on its way through clearing. At least 4 times is expected on average.

Bundles are then put into bags for transfer to branches by van (and rarely, by G.P.O.). Each branch can expect two such bundles of cheques. One bundle contains captured items that were not rejected by the machine. [A machine list accompanies these items.] Another bundle contains the hand-sorted items. No machine list is available for these (except in the Clydesdale Bank). The branch must inform Head Office of all the accounting data on these hand-sorted cheques. At the same time the branch is expected to identify any differences between the bundles and the machine lists and inform Head Office accordingly.

5.3.1 Credit Clearing

Credit Clearing is not yet a fully automated system, but agreements have been reached between the banks on a standard codeline, and paper quality has also been standardised. Full automation will be introduced from 1982 onwards.

Although from the point of view of Data Processing there is no difference between a credit and a debit, there is good reason for the delay in automating credit clearing.

The problem is one of data input. In order for any movement to be made basic data is needed in each case - the bank and branch sort code number, the account number, and the amount, be it positive or negative. In the actual data processing both credits and debits require the same degree of sorting, and the same kind of change - addition or subtraction - at the account.

However, from the point of view of automation and data entry there is a major difference between cheques and giro credits. With cheques, the account in which the movement finally occurs is the account of the customer who issues the cheque. Each customer has a finite number of current accounts, and at the outset knows in advance which accounts he is affecting with his debits. Series of cheques represent debits on one account only. The same data - bank and branch sort code plus account number - is used repeatedly. Thus a bank can issue to a customer a set of cheques which is pre-encoded in machine-readable form with this frequently used data. These cheques can be serially numbered. This printing can be automated and done on a large scale, thus reducing the cost of producing encoded cheques. Only the amount is then requiring to be encoded when a cheque is received at a bank. Thus manually operated encoding machines need only be used for the amount. This is on average 4 digits, less than one fifth of the whole code line on a cheque.

With giro credits, however, the issuer of the credits has no way of knowing in advance what accounts will be credited. For each customer there is potentially an infinite number of destination accounts. Since the purpose of giro credits is to allow remote crediting of money it is implied that the receiver of the money cannot readily give a payer one of his own standard giro credit vouchers, pre-encoded with his account data. The payer, therefore, will prepare manually a credit voucher with sort-code, account and amount numbers which are random in origin. Thus for credit vouchers to be machine-readable all the data must be encoded on receipt by the bank. This represents some five times the work involved with a cheque, and makes automatic sorting of giro credits considerably less attractive economically.

Large receivers of giro credits do issue standard forms to their customers, mainly encoded in optical character recognition (O.C.R.). However, there are still in addition very large numbers of giro credits which are not pre-encoded in any form, and there will always remain some which will never be pre-encoded.

In the absence of automation, the physical work of sorting credits must be carried out by clearing staff. In addition, data on credits must be transcribed by clerical staff, and then entered into the accounting system.

Both the Bank of Scotland and the Clydesdale Bank have begun automation of the credit clearings. The Bank of Scotland has introduced a system of automated remittance from Head Office to other banks. In this system, vouchers received in listed bundles at Head Office are encoded with an MICR line, which allows a reader-sorter to identify the bank to which the voucher is to be sent and the amount. The data is recorded on magnetic tape, and processed to produce full lists of the vouchers remitted to other banks.

The Clydesdale Bank has chosen to automate the inclearing of credit vouchers, that is, the distribution to its own branches of credit vouchers received through the Clearings. For this, coding is required for branch sort code, account number and amount, and also the number of days deferment that will be imposed on the credit before it is posted to the recipient account.

Both the Bank of Scotland and the Clydesdale Bank use NCR medium-speed reader-sorters for their automated credit clearings.

5.3.2 Comment on Automation

For both credits and debits, vouchers are moved, as they always were. It can thus be seen that computerisation has made virtually no difference to the physical processes involved in paper clearings. Paper is still received at branches, sent to head office, exchanged with another bank after sorting, and thereafter sorted again and sent out to the branch where it belongs.

The automation of the physical movement of paper has replaced people by machines. The machines carry out the same process, and can sort vouchers faster than the staff who would occupy the same space.

The main difference arising from the automation of the debit clearings is that whereas, before data on cheques was transcribed clerically to the accounting system, the reader-sorter uplifts the encoded data on the cheque. Such captured data can then be input directly to the central accounting system.

5.4 The Clearings as a data transfer system

Cheques have been sorted and returned to the account-holding branch since their invention, because, without the data contained in the cheque the branch did not have enough information to keep the account for the customer, let alone pay over the money. Thus, the cheque formed part of the base of data of the customer accounting system.

When the manual clearings, in which cheques were sorted into pigeon holes, were found to be inadequate for the growing volumes of vouchers, a computer solution was sought.[4] However, in the 1960's limitations in computer capability did not allow for any solution that did not transmit the actual cheque to the branch. Thus, the automatic reader-sorter was invented, which read the pre-encoded line on the bottom of the cheque, and sorted it to the correct pigeon hole.

It was a natural extension of this system to encode the amount on the cheque so that the total owing from any branch could be calculated during the physical sort.

The reader-sorter could be used even more powerfully as an inputting device to the accounting system itself, using the full codeline of serial number, sort-code, account number and amount, and sorting this data for direct posting to the appropriate account. Thus, in addition to replacing the hand-sorting of cheques, the reader-sorter also replaces the transcription of data from individual cheques to ledgers.

5.4.1 Limitations of the System

However, the vast majority of data on cheques and other vouchers never enters the computer, but is carried through the system by vouchers which are physical data carriers. Data is not completely entered to the information system at any stage, but the vouchers themselves are sent to the customer for him to use to complete his own picture of his account. Other users, likewise, are not provided with full computer-prepared information. Branch managers for example, examine cheques to determine customer behaviour, using data which is not part of the uplifted code-line.

Thus both these information system users are not provided with full information by the system, but instead are provided with outline information (the customer statement) and a bundle of data (the vouchers). Thus the automation of clearings provides a data transfer system which means that currently the Banks do not have computer-based information systems.

5.4.2 The question for the future

The question must therefore be asked whether a base of data can be set up within a computer system to provide for the means to transfer all data and produce all required information.

This question can be restated: must vouchers be moved? Is there technology available that can replace or at least reduce this movement of paper? This is the fundamental question that faces future bank systems designers. Chapter 9 examines this question further.

5.4.3 The legal position of the cheque

Before examining how to reduce the movement of paper vouchers in the Clearing systems, it must first be asked whether it is permissible to do so. Can a bank deduct money from a customer's account in accordance with the instructions on a cheque without having the actual cheque in its possession? (It is an interesting human fact that no-one objects to money being credited to an account without substantiating paper, so the problem revolves around the legality of debiting).

A cheque is defined in law as "an unconditional order in writing addressed by one person to another, signed by the person giving it, requiring the banker to pay on demand a sum certain in money to or to the order of a specified person or to the bearer."

Thus the features of a cheque are that it is

1) unconditional
2) addressed by one person to another
3) signed by the payer
4) for a sum certain in money (with the amount in words being the correct sum in terms of the Cheques Act 1957)
5) payable to a specified person, or to his order, or the bearer.

The cheque is a negotiable instrument, being the equivalent of money when passed from one person to another.

The returned cheque, paid by the branch, is, because the cheque is a negotiable instrument, legal proof of payment. In addition it is also legal authority to the branch to pay from the account. Thus it also embodies indemnity for the branch from claims against it by a customer for debiting his account.(22)

With modern technology, computer systems do exist which have comparable attributes. Print-outs of computer-stored or microfilm images of documents are accepted in the United Kingdom as being equivalent to the original document and thus, for example, as authority to make payments.

Computer-held data on electronic accounting systems can be used as evidence of payment provided it includes a statement of the payee name and date of transaction. Photocopies of cheques are themselves accepted as proof of payment. It is therefore within current thinking to suggest that the cheque itself is not essential if, when required, a copy of the cheque, or a reliable statement of all relevant contents, can be produced.

The branch at which the current account is held must be convinced of the validity of the cheque, and of its technical correctness before it can be paid out. In theory, when a branch receives a cheque it examines it to determine that no irregularities have occurred, and in addition that the signature (or signatures) is as authorised. It should also check that if a Bank card has been used the correct card number is quoted.

Thus it would appear that, for these checks to be carried out, the branch needs the cheque or a reliable copy of the cheque.

Mainly for these reasons the cheque has remained in the Clearing System.

5.4.4 Electronic Funds Transfer Systems

Parallel with the voucher clearings however, there exist several forms of Electronic Funds Transfer, mainly the Standing Order and Direct Debit Systems, using the Banks Automated Clearing Service (BACS) which deals virtually exclusively in magnetic media. All three Banks subscribe to BACS.

The BACS system is intended for all standard money transfers that do not need an accompanying voucher. These money transfer types have come into existence because of the capabilities of computer equipment. Users prepare tapes of all items to be remitted. These are coded in standard format. BACS sorts all tapes at its computer centre, and transmits, or otherwise passes, sorted data to user banks. The data is then input into the bank's accounting system. This system produces a negligible number of vouchers, and therefore does not have much impact on the paper clearings.

The London Clearing Banks and the Scottish Banks introduced the Direct Debiting Scheme in 1967. This scheme is designed for creditor organisations, such as Insurance Companies, Local Authorities, and other organisations which are accustomed to receiving large volumes of payments at frequent intervals. It is not, however, suitable for "non-corporate bodies without perpetual succession, because in the case of such bodies the Indemnity liability falls directly upon individuals without limitation."

In the scheme, the party to be credited collects amounts due to him direct from the payer's bank branch using an accounting entry prepared in the form of a magnetic tape record or as a paper voucher. Explicit consent to apply direct debits must be obtained from the payer, in writing, and this must be lodged with the Bank branch, before debiting is allowed to take place. Such a written instruction is called a "mandate".

This is the only system recognised by the Banks which lets a payer authorise payments, until further notice, of sums variable at the discretion of the payee, both in payment date and amount. (This is, for example, a direct contrast to the Standing Order system, in which a change in either amount or date requires a new standing order to be set up).

Data on a Direct Debit form is:

Date

Sorting code number of Bank Branch to be debited

Name of Bank and Branch to be debited

Amount

Name of account to be debited, and account number

Originator's reference (optional)

Name of Originator

Name and sorting code number of originator's Branch

Vouchers must also be identified as FIRST PAYMENT, or FINAL PAYMENT or RE-PRESENTED voucher. On magnetic media, these are given different transaction codes.

This scheme allows a third party to operate on an individual's bank account with a minimal level of scrutiny, and this is an extremely powerful capability. The Banks are therefore very careful to assess prospective originators before they are sponsored as members of the scheme.

Branches have the right to return a direct debit unpaid if circumstances warrant it, although payment or return must be done within the same time cycle applicable to cheques.

The Direct Debit system is specifically designed as a fully computer-based system.

5.4.5 Cheque Truncation

Aware of the success of Electronic Funds Transfer Systems such as the Direct Debit System, banks have proposed the removal of cheque clearing by using Cheque Truncation. As so far proposed, this involves the continued use of MICR encoding and of fast reader-sorters.

In essence the suggested procedure is that the code line remains as at present, with full reciprocal amount encoding between banks also as at present, with the burden of checking for technical faults on the cheque (as opposed to the account on which it is drawn) falling fully on the crossing bank, with the liability for inadequate checking falling, however, on the paying bank. The reader-sorter would uplift the code-line as at present, and this data along with the crossing bank code would alone be passed over to the inclearing bank, with the possible addition of those cheques which had been incompletely encoded, and had, for example, no account number.

In order for cheque truncation to be accepted it must provide sufficient information to the customer to satisfy his requirements of accuracy, security, proof of payment and indemnity.

Table 5.3 contrasts the Direct Debit System with current proposals for cheque truncation. From this table it can clearly be seen that there are significant objections to current proposals for cheque truncation systems. The chief objections are based on the inaccuracy of current clearing systems, (see Chapter 8) and the inability of cheque truncation schemes to provide the branches with adequate proof of instruction to pay from the customer.

TABLE 5.3

Comparison of the Direct Debit System, and Cheque Truncation Schemes.

	Direct System		Cheque Truncation Debit System
1)	Deductions by responsible institutions vetted by the banks.	-	deductions by any party likely to receive a cheque.
2)	Full indemnity for the bank.	-	reduced indemnity.
3)	Full knowledge of identity of Originator at each application	-	no identity of payee.
4)	Proof of payment in customer statement.	-	no proof of payment because identity only by serial number and own-records.
5)	Security under terms of direct debit mandate held at customer's branch.	-	cheque can be altered before presentation to a crossing bank.
6)	Signature for authority is on mandate at customer's branch.	-	the signature can be forged and not thereafter available for branch or customer verification.
7)	Easily reversible procedure through standard computer system, and full knowledge of Originator.	-	lack of payee identity makes reversal difficult or impossible
8)	Input preparation requirements imply negligible data corruption.	-	input via MICR allows significant level of data corruption.
9)	Branch can check the debit for technical errors.	-	this is not possible except for technical deficiencies in the account.
10)	Fully numbered in sequence so that duplication can be detected.	-	the absence of a serial number would not invalidate the cheque. Therefore duplication could not easily be detected in such cases.
11)	Date of deduction recorded.	-	no record of signing date of cheque.
12)	Current legal requirements are for mandate, which is already at the branch	-	currently the cheque is legally required by the branch before payment.

What makes cheque truncation as so far proposed unsatisfactory is that data uplift in current forms is unreliable, and also that inadequate information is passed to the principal users - the branch and the customer - to allow for full checking of transactions, and also to establish proof of payment, and present full customer transaction records on statements.

Cheques are, legally, negotiable instruments, and, as instructions to a banker to pay from an account, must be seen by the banker. The law on negotiable instruments is itself an obstacle to cheque truncation.

Traditionally the cheque itself, returned to the branch and returned to, or available for, the customer, provides all the necessary data and safeguards for branches and customers. Before any cheque truncation system can be installed the branches and customer must fully accept that it is an alternative system that gives them all of the information previously available to them, and all of the security of the paper-based system. Only full uplift of data on vouchers can do this. Only when a full uplift system has been proposed, could the legal problem of the paper cheque itself being a negotiable instrument which requires to be returned to the branch be tackled.

Thus, in default of full uplift of data on vouchers, the vouchers themselves must be passed to the account holding branch, and thence to the customer. Thus Bankers have never agreed on cheque truncation.

5.4.6 Comment

From this chapter it can be concluded that:

- the Banks use chiefly a daily batch updating system for their data processing
- for the Clearings, automation is used, and the paper, on which is the data required by the Banks, is sorted by machine and transmitted physically
- thus the Banks have a paper-based, and not a computer-based information system, as not all the data is within the computer.

Banks have discussed removing paper from the system, using cheque truncation and electronic funds transfer.

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The inability of banks to agree on an electronic funds transfer system to replace cheque usage has effectively dictated that automation be the chief mode of computerisation of the Clearings, and made it impossible for them to set up computer-based information systems.

In spite of this, the use of computers has proved an economic advantage, as is now demonstrated in Chapter 6. This starts with a discussion of the growth in staffing over the decade, but goes on to show that the growth would have been considerably greater without computers.

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Chapter 5 : Notes and Bibliography

1. All statistics quoted in this chapter have been extracted from Bank records. Similarly, all qualitative information has come from an examination of the Banks' systems, and from accounting manuals and computer systems specifications used in the Banks.

2. "Cheque truncation - flight of fancy or force majeur" Tom Bell
The Bankers' Magazine. March 1980.

3. "Centralised Accounting - the 3600 Terminal System"
The Bank of Scotland. (Publicity) 1979.

4. A cri de coeur of one Clearing Manager - "We brought in the computers, and we're the last to get the systems".

5. The net position in the Banks is that deposits are increasing (see Chapter 3) which demonstrates that a net outflow of money when all forms of transmission are considered cannot possibly exist on average.

6. "Automation - Getting Rid of the Paper" p 126 Scottish Bankers Magazine May 70

7. "The Clearing System - private & public" J Hunsworth.
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8. "Check-Clearing Made Profitable" D Carreker
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H Thomas The Bankers Magazine 1977

12. "EFTS & the Structure of Banking" P C Eisemann
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14. "Advances in electronic funds transfer." L S Simon
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17. "Payment Systems - a transatlantic convergence"
Marjorie Greene The Banker Sep 78

18. "Preparing for EFT" H G Johnson, E C Arnold.
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19. "The Market for Money Transmission Services in the U.K."
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20. "The Effects on the Banks' Money Transmission and Related Activities of Changes in the Postal Services"
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21. "The Costs of Money Transmission 1976"
I S Trowbridge IBRO No. 191 Dec 77

22. Thus it might be argued that a Branch needs to have a copy of a cheque after payment; currently this is not the case.

23. "Truncation of Cheque Clearing"
IBRO No. 107 1972

24. "Where Payment Systems are Going" T McMillan (Nat West)
Paper to 3rd Payment Systems International Conference
Toronto, Oct 1973

25. "Future of Paper Handling Systems" Alain Hilliard
Papers to 3rd Payment Systems International Conference
Toronto, Oct 73

26. Appendix E gives some further details on various account types.

Chapter 6 : The Economics of Computerisation

6.1 Staffing for Retail Banking

It has been stated above that the major impact of computerisation has been in automatic cheque sorting and centralised customer accounting.

No conclusion can be reached about its value without considering the impact on staffing for the retail functions of the Banks, in particular, those staff working in the actual retail outlets, the branches. These staff are involved in data input, some information processing, and information dispersal.

Data for retail banking enters the system from a number of sources viz:

1. via the teller at a branch counter
2. from correspondence received at branch back office
3. from electronic money transfer systems (BACS, Standing Orders, etc.)
4. from automated clearing
5. from accounting system records (interest, bank charges etc.)

Until recently only the last three of these were computerised. At the present time (1981) the Royal Bank of Scotland and the Clydesdale Bank are in the process of computerising the first two, but over most of the decade 1970 - 1980 this aspect of customer accounting remained uncomputerised, and with the growth of customer account numbers, the clerical work carried out by tellers and back office staff has increased.

Similarly, although data leaves the system in an advanced form, there is still some manual work left before statements can be sent to customers. Cheques must be called off against statements. They must be packed into envelopes, and prepared for posting. Incorrect statements must be retyped. Ledgers must be updated. In fact, a great amount of mundane routine work remains before the accounting work can be considered over.

In addition, branches carry out other customer services, such as loan advancing, giving general financial advice, and attracting new accounts. General administration - staffing, property maintenance etc - also increases as other factors increase staff and property requirements.

This has been reflected in a growth in the average number of employees in branches (as seen in TABLE 6.1). In spite of rationalisation of branches since 1973 an average growth of over 3% per annum in branch staff has been experienced. At the same time senior staff in branches have increased in number by only 1% p.a. on average, an indication of the lower grade nature of work which has been left at branch level by computerisation.

Branch numbers are not, of course, completely described by an average figure, as certain branches are considerably larger than the average. There is also a minimum level below which a branch would not be staffed. Since each branch requires a manager, an accountant, a ledger clerk and a teller, this minimum number, probably never attained, would be 4. The most common number of employees in a branch is about 12.

Recent years have shown the arrival in Scotland of computer equipment designed specifically to relieve branch work by removing some of the clerical work associated with accounting. These are cash issuing terminals, and teller terminals. The former is in the main designed to remove the cash-cheque - this being the cheque presented over the counter by an individual in order to withdraw cash from his own account. Survey has shown that over 40% of cheques written by individuals come into this category. A high proportion of these cheques never enter the clearing, as they are paid at the branch where the customer has his account. Cash pay-out, because of the time required to retrieve, count and check money, represents one of the larger jobs carried out over the counter.

Teller terminals, on the other hand, are designed to decrease back office labour, particularly on deposit accounts. These accounts must have the pass-book fully updated at each transaction which requires access to ledgers. Copies of these ledgers are held in the back office, but where teller terminals are available these can give direct access to the computer where a summary ledger is held on file, which can be displayed to the teller and enable her to update the pass-book immediately. The search is therefore virtually instantaneous, there is no manual ledger updating, and no back office terminal input required. The teller has the additional job of transcribing displayed accounting data to the passbook, although this too can be automated.

		1970	1973	1975	1977	1979	1980
Branches	Grades I - IV	2192	3870	3930	3956	4191	4257
	Grades V & upwards	517	925	919	901	988	997
	Part-time & N.C.	Not Available	122	207	438	737	832
Add - Computer Services							
	Grades I - IV	177*	101	162	194	201	198
	Computer Services Grades V & upwards	54	86	128	131	147	165
	Computer Services Part-time & N.C.	Not Available	44	28	26	37	53
		-	5148	5374	5646	6301	6502
Departments excluding Computer Services P.F.S. International Economist Corporate Planning							
	Grades I - IV	Not Available	441	454	426	431	442
	Grades V & upwards		181	215	249	324	367
	Part-time & N.C.		177	229	282	311	369
		-	799	898	957	1066	1178
TOTAL RETAIL STAFF			5947	6272	6603	7367	7680
Group Employees per Annual Report (average number of persons employed each week)		6753	7437	7851	8332	8791	9112

* The figure of 177 for Computer Services Grades I - IV included approximately 80 Clearing Department staff. From 1973 onwards Clearing Department staff are incorporated in the figures for "Departments".

NO COMPARABLE FIGURES ARE AVAILABLE FROM THE OTHER TWO BANKS, BUT THE PATTERN IS SIMILAR

TABLE 6.1

BANK OF SCOTLAND - STAFF NUMBERS

TABLE 6.2

AVERAGE NUMBER OF EMPLOYEES AT BRANCHES OF THE BANK OF SCOTLAND

YEAR	TOTAL*	AVERAGE
73	4917	11.7
75	5056	12.3
77	5295	13.8
79	5916	15.7
80	6086	16.1
AVERAGE ANNUAL GROWTH	3.1%	4.7%

* INCLUDES PART-TIME STAFF

NOTE: THE CLYDESDALE BANK AND THE ROYAL BANK HAVE BEEN UNABLE TO PROVIDE COMPARABLE FIGURES.

AT 1980, THE ROYAL BANK OF SCOTLAND HAD AN AVERAGE OF 16 STAFF PER BRANCH, THIS HAVING RISEN FROM 11.5 STAFF PER BRANCH AT 1971.

TABLE 6.3

The Royal Bank of Scotland Limited : Staff figures.

Year	Weekly average staff employed (Bank and subsidiaries)	Aggregate Remuneration during year £'000
72	7,164	10,553
73	7,459	11,625
74	7,795	14,706
75	8,180	19,648
76	8,278	23,208
77	8,692	25,997
78	9,064	29,921
79	9,504	39,126
1980	9,625	46,464

Average annual growth in staff numbers : 3.8%

Table 6.4

	Outlay on Equipment £'000			
Figures from Annual Reports	RBS	RBS*	B of S	C.B.
Net Book value at start of decade 70 - 80	1,064	259	2,987+	1,340
70	684	40	1,916	508
71	1,175	27	1,221	666
72	1,285	104	1,061	595
73	2,410		683	866
74	1,069		1,312	722
75	3,350		4,886	1,218
76	1,812		2.463	1,561
77	2,611		3,571	2,025
78	3,193		3,258	3,167

AT 79 AND 80 ALL THREE BANKS WERE INVOLVED IN EXTENSIVE PURCHASES OF NETWORK EQUIPMENT AND EQUIPMENT FOR NEW BUILDINGS.

RBS - Computers, office equipment and motor vehicles.

B of S - Fittings, furniture and machinery.

C.B. - Furniture, Fittings & Equipment.

RBS* - Furniture and fittings

From 1973 RBS gave only one figure for "computer and other equipment."

+ Gross book value at 28th February 70.

B of S) - "replacements of sundry office equipment are charged
RBS) to revenue."

Such developments are expected to contain branch staffing numbers. The Royal Bank of Scotland for example, claims that it intends that its Cashline and Teller Terminal systems should prevent further growth in staff.

It should be noted that the proportion of retail staff to total staff is considerably higher than the proportion of retail to total managers (as set out in Chapter 3). This reflects

a) the specialised nature of non-retail banking which requires a few highly qualified staff, and

b) the highly computerised nature of the non-retail functions which decreases the total numbers of clerical staff required.

(It should be remembered that the Scottish Banks are still predominantly retail banks, with the greater part of their computer power directed to retail processing).

The decade has seen considerable growth in the numbers of computing personnel, alongside considerable investment in computer and other equipment. (TABLE 6.4). The cost of computer equipment has dropped steadily in real terms over the decade. However, the cost of accepting vouchers, sorting them and preparing them for despatch to branches and other banks, has increased faster than the rate of inflation (as shown in TABLE 6.5) over the decade 1970 - 1980.

This high rate of increase is in part due to the fact that the work involved in sorting increases exponentially with volume. This is not immediately obvious, because the number of destinations of the sort is not increasing at the same rate as the volume of the sort. However, companies, which issue the majority of cheques, have over the years come to demand the sorting of their returned cheques in serial order.

In addition, during the decade, the high profits in banking have enabled staff to demand salary increases in excess of the average rate at the time. Further, the staff involved in clearing includes a very high proportion of lower paid manual and clerical workers who benefited, in relative terms, from the flat rate pay increases imposed by the Labour Government during the mid-seventies.

These factors together have caused clearing to become relatively more expensive over the decade. Since automatic sorting was one of the earliest of computer applications most savings would already have been experienced before 1970.

TABLE 6.5

COST OF SORTING VOUCHERS IN HEAD OFFICE CLEARING IN THOUSANDS OF POUNDS STERLING PER MILLION VOUCHERS

	YEAR PRICES	JAN 1970 PRICES
70	4.54	4.54
71	5.88	5.42
72	6.05	5.15
73	6.25	4.94
74	8.67	6.12
75	10.75	6.33
76	13.36	6.38
77	13.95	5.71
78	14.87	5.54
79	16.72	5.70

This is only one component in the total cost of clearing vouchers. In addition there are the following costs:-

* computer time for voucher sorting
* computer time for account updating
* transporting vouchers between branches and head office, and to other banks
* accepting vouchers at branches, both over the counter and at the back office
* terminal or other clerical time for data entry
* error correction and auditing
* posting cheques with statements to customer.

To a greater or lesser extent all of these aspects of the total cost are volume dependent and all except the computer time cost have increased at least in line with inflation over the decade.

The rising nature of item costs in real terms combined with increasing rates of clearing usage per account over time has the effect of increasing the real average balance that must be held in a current account before that current account can be considered profitable (given that interest rates and all other variables remain constant). Since, as has been seen earlier, average balances are in fact dropping in real terms, there is concern also for reducing real item clearing costs in order to maintain bank profitability. In recent years, with high ruling interest rates, this concern has been reduced, but with the reducing interest rates of the very recent past there is growing awareness among bankers of clearing costs.

Various estimates have been made by IBRO and others of the actual total cost of clearing a voucher. At 1980, one estimate suggests a cost of 24p per item.

In TABLE 6.6 a conservative estimate is made of the voucher clearing cost at 1980 prices, excluding computer time.

This is the suggested cost for any voucher, debit or credit, relating to current accounts. At 1980 the charge to personal customers set by both the Royal Bank and the Bank of Scotland was 12p per cheque, with no charge for giro credits. Those personal customers of the Clydesdale Bank whose accounts fell below zero during the charging period were similarly charged.

In Table 6.6 an average cost is estimated, and shows the order of magnitude that would be experienced by the Scottish Banks. It does not break costs into fixed and variable components because this thesis is concerned not with the negligible marginal cost of adding one more cheque to a system, but with the substantial effects that would be felt if, say, the volume were halved or doubled. In these circumstances, average costs are the relevant figure.

It must be commented that in this estimate by far the greatest component refers to the manual involvement at branch level. A considerable proportion of this manual effort is spent in the back-office lodging those cheques which were sent out unlisted by Head Office. Therefore, the removal, or even reduction of the manual sort would have the effect of reducing that component of the total cost.

This manual sort can be reduced by automation of the credit clearings, and by in some way entering the data from rejected cheques into the computer by a reject-re-entry system. All three banks are currently considering such a system. The Clydesdale Bank installed a reject-re-entry system in December 1980.

With such a high manual cost component in clearing, it must be questioned how far the computerisation has been economical.

TABLE 6.6
Estimated cost of processing a current account voucher.

Suppose a bank collects 60m vouchers per annum, of which 20m are in-house. Then 40m are delivered to other banks. Suppose this bank also receives 40m vouchers from other banks. Then its costs will reflect the costs of total passage of 60m vouchers. Costs are in pence.

H/O sorting cost per item		1.67p
Transport to other banks, at £0.1m per annum	0.17p	
Delivery to head office (assuming 5p for 10 vouchers)*	0.50p	
Postage cost to customers, per item (assuming 12 for 12p @ 1980)**	1.00p	
Total Transport Cost		1.67p
Assume 7,000 Branch Staff, costing £70m in total cost, including overheads, with 20% of their time devoted to voucher movement.+		
Branch cost per voucher		23.33p
Error correction staff : assume 30 staff at £300,000 working full time		0.50p
Total - Approximately £0.27 per voucher.		

* a qualitative estimate by bank staff is that van delivery costs half Post Office rates.

** based on an average number of vouchers sent with a statement by first class post.

\+ a qualitative estimate by bankers is that 20% of branch staff time is spent on voucher movement, half being spent on inclearings, and half on outclearings.

6.2 A retrospective assessment of the decision to computerise

It is regarded as obvious to all in banking who work in computer divisions that computers are necessary, have been a worthwhile investment, and will continue to be so. (See Appendix D for one example). This is not taken so much for granted outside computer divisions, and is treated very sceptically by non-bankers and members of the general public. It is therefore the intention here to examine the cumulative cost of running a banking business over the sixteen years 1965 - 1980 in Scotland, grossed up to 1980 prices, using the retail price index, on various assumptions about the point in time at which computerisation started, and about the growth in bank business.

Before embarking on any new venture involving financial outlay a profit making organisation, such as a bank, must be satisfied that the venture will show adequate returns. In the case of technological change, future costs under the changed environment must be compared with future costs under an unchanged regime, and the difference compared with the cost of carrying out the change. Decisions must be made on the basis of future profitability, or a net saving in future costs.

This section looks at the outcome of computerisation in a general bank, and compares this with the information that would have been available to managers taking the original decision. It is assumed that until 1965 this general bank had no computerisation programme, and that once the decision to computerise had been taken, it was irreversible. Various values are taken for growth parameters, and other variables.

The result of the analysis is that a bank with a staff at 1965 of about 2,000 should at that stage have begun a programme of computerisation. It is interesting to note the historical facts in this light - all five Scottish Banks existing in the 1960's did have computerisation programmes at 1965. The smallest at that time, the British Linen Bank, approached the 2,000 staff threshold. The Bank mergers of the late sixties greatly enhanced the savings from computerisation for both the Royal Bank of Scotland, and the Bank of Scotland.

6.2.1 Information available to Bank Management at 1965

No Bank made available to the author any contemporary reports justifying computerisation in the early sixties. Historical papers suggest that the motivation was the growing volumes of paper clearings. The economics of the actual decision can, however, be reconstructed in broad terms, using a discounted cash flow calculation, with figures that were available at 1965.

At that time it could be observed that staff numbers were increasing at 4% p.a.; ruling rates of interest suggested a required net return on capital of 3% p.a., and this would have been taken as a discounting factor; salaries and expenses could be expected to increase at 2% p.a. per member of staff. Computers, for Banks the size of the then existing Scottish Banks, would come in one price range, of up to £3m. They would probably require replacing after five years, but the systems that had been written for use in them would be able to be transferred to the replacement equipment, and thus the systems could have a ten year life. Computers would be expected to stop growth in staff numbers. It would be hoped that computerisation would show a net positive return in five years (in other words that capital outlay would in that period be completely recovered), and so a five-year time horizon would be considered. However, it was also meaningful to consider a ten-year time horizon, to allow additional time for the systems developed for the first computer to return their full value. Thus, the decision could be made on the basis of calculations set out below.

A discounted cash flow approach to a decision on computerisation.

In this analysis £m means "million £".

Assumptions:

* Staff growth p.a. without computerisation = d = 0.04 p.a.
* Net return required on capital, = j = 0.03 p.a.
* Salaries, expenses etc will increase in cost at q = 0.02 p.a. irrespective of whether or not computers are used, as the cumulative result of general price trends etc.
* Outlay on computers will be initially £3m, with computers requiring to be replaced after 5 years at the same nominal cost (i.e. reduced real cost)
* Computerisation will remove the need to increase staff numbers
* Total salary, expenses etc per staff member at 1965, c = £2,000p.a.
* Total staff numbers at 1965 = X thousands
* Time horizons are taken as 5 and 10 years = L.

Present value at 1965 of cumulative difference in staff salaries and expenses over the time horizon as a result of computerisation can be expressed by the formula

$$T_L = \sum_{t=0}^{L-1} \frac{X c (1+q)^t \left[(1+d)^t - 1\right]}{(1+j)^t}$$

Thus the calculated saving which would have been available for computerisation was

* on a five year time horizon

  T_5 = £m 0·92 per 1,000 staff at 1965

* on a ten-year time horizon

  T_{10} = £m 2·98 per 1,000 staff at 1965.

On a 5 year time horizon, a staff of about 3,500 would have been required on this basis before computerisation could be recommended. However, on a 10 year time horizon, a staff of about 2,000 would have been sufficient to justify computerisation.

The Scottish Banks all decided to take up computerisation by 1965, and their decisions appear to have been economically justified at the time. However, few of the assumptions above were borne out in the event. To assess the situation as it actually happened, the effects of computerisation on cost will now be considered retrospectively.

How far the expectation of savings has been borne out can be estimated using models based on the experience so far observed for the three Banks.

6.2.2 OBSERVATIONS

1 Over the 16 year period, in spite of continued effort in developing computer systems, staff in the Scottish banks has increased, at an average annual rate of about 4%.

2 Over the same period, the number of transactions over bank counters has risen at an average annual rate of about 9%. The number of cheques passing through clearing has risen at an average annual rate of over 12%. Credit clearing volumes have grown at an average annual rate of about 12 - 15%. Other services, such as Direct Debiting, BACS giro credits etc have appeared, and are growing annually. Standing orders are increasing at a rate of up to 30% p.a. The number of accounts has risen at between 5% and 9% p.a. In addition, considerable extra services are now provided by Banks for their customers.

3 Over the sixteen year period, the cost of computers has fallen in real terms. The capital outlay on computers, office equipment and vehicles is given in the notes to annual accounts by each bank. (See Table 6.4) Banks do not have large fleets of vehicles, and as a conservative approach in the analysis the total outlay is taken as an indication of annual costs of computer equipment. Costs for equipment are therefore an overstatement of experience, and so cause an understatement of the advantage of computerisation. "Equipment" also includes furnishings for new offices; again this implies that cost for computer equipment is below the whole outlay on equipment.

4 Banks own the vast majority of the property used by them. However, property used to accommodate bank staff represents an opportunity cost to the bank in terms of annual rent foregone. The variation over the 16 years of rent prices in commercial property in Glasgow is known. This is used as an indicator of the variation in opportunity cost of bank property over the 16 years. Property costs represent a high proportion of the non-computer costs in non-salary bank costs, and are in some of the models below taken as an indicator of other non-computer costs.

Cost of premises index - source Richard Ellis Research, Glasgow 1980.

yr	index	yr	index
65	100	73	225
66	112	74	280
67	120	75	400
68	130	76	440
69	145	77	465
70	160	78	480
71	175	79	520
72	200	80	545

5 The Royal Bank of Scotland and the Bank of Scotland publish total staff numbers and total salary bill at each year in their annual reports to staff. This can be used along with generally published salary rates as an indicator of the variation over time of average salaries of staff members in Scottish Banks. (TABLE 6.3)

The retail price index at July of each of the years 1965 - 1980 is known, and is used to gross up to mid-1980 prices any sums relevant to years 65 - 80. This index is set out in Appendix A.

6.2.3 Comments

The total number of premises used by a bank depends mainly on its branch system. However, the total area that is required by a branch is dependent mainly on the number of branch staff required. The total office area required at headquarters is effectively directly dependent on staff numbers. The amount of property required can therefore be regarded roughly as directly dependent on the number of employees. Since, in addition, in banking hundreds of separate properties are used, the expense of running and upkeep can be considered a continuous variable dependent on total office area. Some account could be taken of the space used by computer equipment. However, for very large staff numbers, such as exist in all Scottish Banks, this adjustment is small. Computers have become less bulky over time, so that the area required has decreased, and the opportunity cost of the area decreased in real terms over time.

Cost of premises index - source Richard Ellis Research, Glasgow 1980.

yr	index	yr	index
65	100	73	225
66	112	74	280
67	120	75	400
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71	175	79	520
72	200	80	545

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6.2.4 The retrospective cumulative cost of computerisation

In order to assess whether the Scottish Banks have benefited in cost terms from computerisation, a model of cumulative costs at January 1980 prices was used.

Figures in the models set out below derive from general assumptions, some of which were varied in each application of the model. The model estimates the cumulative cost to a bank in 1980 terms as a function of staff numbers at 1965, under four regimes:-

1 Computerisation began in 1965

2 Computerisation began in 1970

3 Computerisation began in 1975

4 Computerisation began in 1980

The assumptions give the order of magnitude of cumulative cost differences over the 16 year period dependent on staff numbers at 1965. They cannot in any application of the model be regarded as an accurate statement of any bank's cumulative costs over the term.

In the model, cumulative costs are assumed to consist of three components:-

a) a staff component, consisting of total salaries,

b) a property and other costs component, consisting of overheads,

c) a computer component, consisting of direct computer costs,

The tables of results for each Model, set out below, give for the four regimes the three cost components for the complete 16 year period, and consist of totals for 16 years of each year's costs at 1980 prices.

In the graphs, the four regimes are identified by the year of first computerisation.

FIG 6.1 demonstrates that each total figure consists of one component which decreases as computerisation is delayed (the computer component) plus two which increase with delayed computerisation. The result is that for every application of the model there is a number of staff at 1965 (a cross-over number) for which the bank's cumulative costs over the term would have been indifferent to computerisation. Computerisation is seen (in FIGS 6.2 and 6.3) to have greater cost advantages the higher the staff numbers at 1965. These graphs are on different scales and for different staff numbers to demonstrate also that the actual cross-over staff number from cost disadvantage to advantage depends on work growth rate.

The number of staff required at each year under each regime was calculated, assuming 1000 staff employed at 1965. This is tabulated in Appendix C. The first horizontal lines on the tables C3 and C8 give the number of staff required at each year assuming no computerisation.

The columns give the future staff requirements if computerisation is started at the year numbered at the head of the column.

For each year, under each regime, the salary bill as a function of staff numbers is calculated as

$$\text{(staff numbers)} \times \text{(average salary at that year)} \times \frac{\text{RPI at '80}}{\text{RPI at year}}.$$

In the case of Models A, C, E and G for each year, under each regime, the other non-computer costs are calculated as

$$\text{(staff numbers)} \times \text{(property index)} \times \text{('65 average cost)} \times \frac{\text{(RPI at '80)}}{\text{RPI at year}}$$

In the case of Models B, D and F, the other non-computer costs are calculated as

$$\text{(staff numbers)} \times \text{(average salary at that year)} \times \frac{\text{(RPI at '80)}}{\text{RPI at year}} \times 0.8.$$

A computer factor was allocated for each year (see Assumption 6 below).

For each year, under each regime, the computer cost is calculated as

$$\text{(computer factor (as in assumptions))} \times \frac{\text{(RPI at '80)}}{\text{RPI at year}}$$

Staff numbers are expressed in X thousands.

The total for the sixteen years for each of the three items is then found. This gives for each regime a cumulative total cost in 1980 terms as a function of X.

RPI is used as an inflating factor because it is tabulated. A more appropriate rate might be the interbank rate on advances (though arguably it could also be interbank borrowing rate). However, this is awkward to use because it is not tabulated over complete years. For the purposes of this calculation RPI does not decrease the accuracy because, over the 15 years, inflation measured by RPI has been sometimes less than and sometimes more than interest rates on funds. Over 15 years the net effect is about the same.

6.2.5 General Assumptions and Conclusions

1 At 1965 other non-computer costs including rent foregone in premises equalled the annual salary bill (see 6.2.2), and that thereafter, these costs have risen in proportion to the index of rents stated in 6.2.2.4.

2 All staff numbers include computer development and operations staff where appropriate, so that no extra costing is required for systems staff.

3 Computerisation requires to be continued if staff numbers are to be contained.

4 Without computerisation, staff are required to increase in numbers at the rate of at least 7% and possibly up to 15% p.a. over 1965 - 1980. Calculations are done at both these growth rates and are identified as 15% Calculation and 7% Calculation. Observation 2 points out the growth rate of various components of work in the Banks. Section 2.3 "Changes within the Scottish Banks" section 3.4 "The Growth of Customer Accounts" and section 3.5 "Transaction and Clearing Volumes" together demonstrate the impossibility of identifying what might have been the case without computerisation. Since the growth in transactions over counters has been at 9% p.a. over 1965 - 80 and the growth in accounts at an average of 7% p.a., it is unlikely that even improvements in productivity would have alone contained staff growth below 7% p.a.

5 There is a build-up in computerisation. If computerisation is deferred, staff numbers will not be decreased on assumption of computerisation, but growth will, after a number of years be reduced to 4% p.a. If staff growth without computerisation had been 15% p.a., in the first year after computerisation growth will be 12%, in the second 9%, in the third 6%, and thereafter 4% p.a. If staff growth without computerisation had been 7%, the reduction in growth rate will take 3 years with annual rates of staff increase at 6% and 5% in first two years, and 4% p.a. thereafter.

6 At first computerisation there is an outlay of £3m. Thereafter there is an annual outlay, at current prices for the year in question following the pattern 2m, 2m, 3m, 2m, 2m, 3m, 2m....(COMPUTER FACTOR in tables)

The use of this pattern allows for three aspects of computerisation over the period 1965 - 80.

a) the cost of computers has decreased in real terms.

b) in line with the observations in FIG 2.4 the Banks have continually added to their computer equipment and have continually expanded their available computer power.

c) while nominal costs for computer equipment in the late seventies were lower than in the late sixties, an additional hidden cost of maintenance contracts and software rental had to be added.

The pattern proposed compares with data in 6.4.

7 In the first analysis, no account is taken of tax. Salaries and expenses would normally be charged against profits for tax purposes in the year in which they were incurred. Equipment would normally in the Scottish Banks be charged against profits on a straight line depreciation basis probably over 7 years. Bought premises might represent a tax liability on appreciation.

8 Average salaries for staff at any year are those set out in Table C.1. Increases in average staff salaries are independent of computerisation.

The eight assumptions above were used in MODEL A. The details of the calculations for Model A are set out in Appendix C.

TABLE 6.7 : RESULTS FOR MODEL A

Cumulative cost over 1965 to 1980 at 1980 prices as a function of the number of thousand staff employed at 1965.

15% Calculation £m

Regime	Salaries	other non-computer costs	computer cost
1	112 X	155 X	107
2	169 X	236 X	57
3	226 X	321 X	21
4	250 X	354 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	101 X	139 X	107
2	114 X	157 X	57
3	123 X	170 X	21
4	126 X	175 X	-

Interpretation: Suppose a bank had 2,000 staff at 1965, and computerised. On the 15% calculation, by 1980, its total expenses, and all the interest that could have been earned if the expenses had otherwise been available, would have amounted to £m(112 x 2 + 155 x 2 + 107). If it had not computerised at any time, total outlay and accrued interest over the same term would have amounted to £m(250 x 2 + 354 x 2). Cumulative costs for computerisation at '70 or '75 lie between these extremes, and are similarly calculated.

Some specific values of X have been used to produce FIGS 6.2 and 6.3.

These can be interpreted as meaning the following:-

(1) If staff growth without computerisation was at 7% p.a. a bank which had a staff of 1000 at 1965 should not yet be computerising, as over the fifteen years it would have laid out more money on equipment than on equivalent staff. However, a bank with more than 2,000 staff at 1965 would have made a saving over the 15 years if a programme of computerisation had been undertaken.

(2) If staff growth without computerisation was at 15% p.a. a bank with 400 staff in 1965 would have paid more over the 15 years if it had not computerised.

Comments

1) Figs 2.4 demonstrate that purchase of equipment by the Scottish Banks has been independent of Bank size, being in fact, more determined by available ranges of equipment. Thus, within the size range of the Scottish Banks (i.e. staffing level up to about 5,000 at 1965) the cost of computers is independent of staff numbers.

   If the model were to be extended to all banks, account would need to be taken of other available ranges of equipment, making the computer cost dependent on staff numbers. In the very recent past mini- and micro- computers have also become available, so that in the future computer costs may be a direct function of staff numbers.

2) In this analysis it is assumed that if property had not been occupied by staff, it could have been rented, thus improving the total income of the bank. The column "other non-computer costs" includes the opportunity cost of this rent foregone (see Observation 4) thus increasing total additional expenses beyond the traditional expectations. The traditional overhead cost does not include such a foregone income, and might normally be considered directly comparable with staff salary costs. This result reflects the property market in Scotland over the 15 year term. During this term commercial property has been an attractive investment compared with other possibilities.

FIG 6.1 CUMULATIVE COSTS OVER 1965 - 1980 vs. YEAR OF FIRST COMPUTERISATION, AT 1980 PRICES.
15% WORK GROWTH. 1000 STAFF AT 1965.

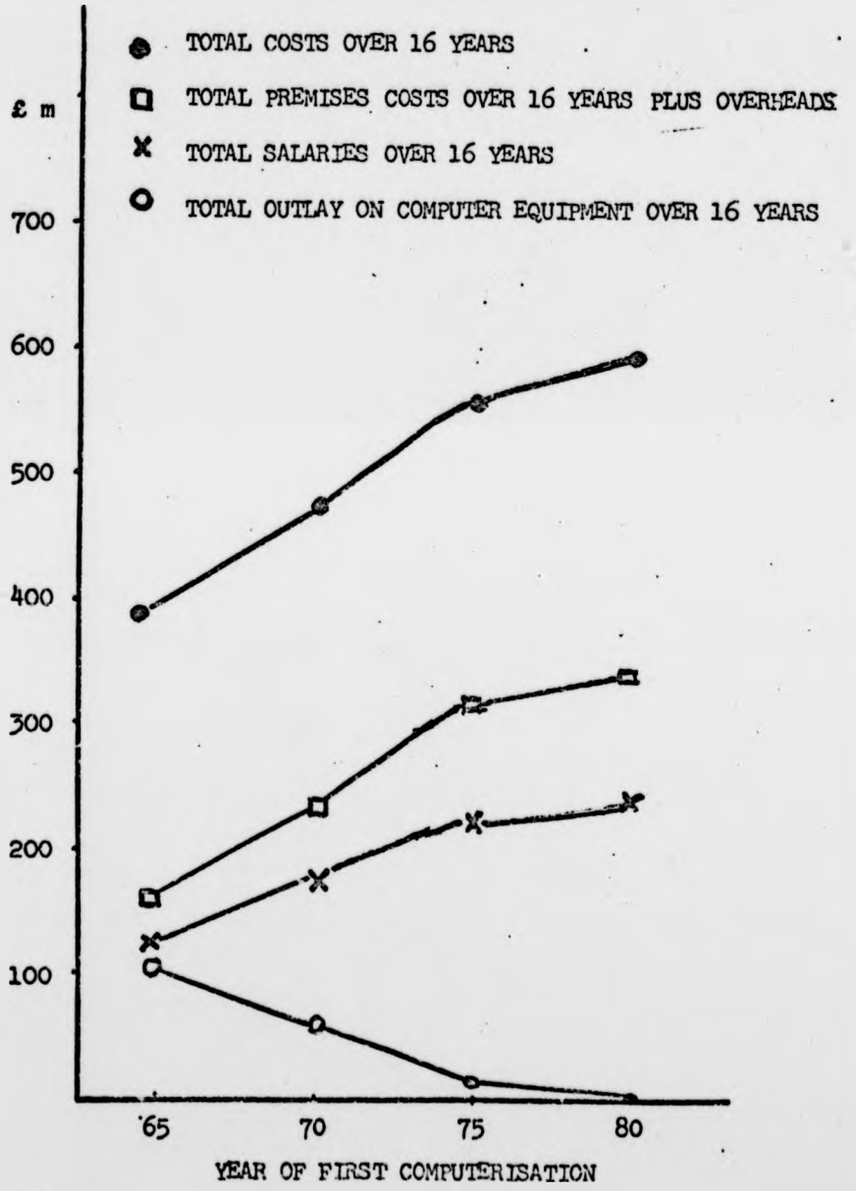


FIG 6.2. CUMULATIVE COSTS OVER 1965 - 1980 vs. YEAR OF FIRST COMPUTERISATION, AT 1980 PRICES, WITH 7% WORK GROWTH.

TOTAL COSTS OVER 16 YEARS FOR VARIOUS STAFFING LEVELS AT 1965.

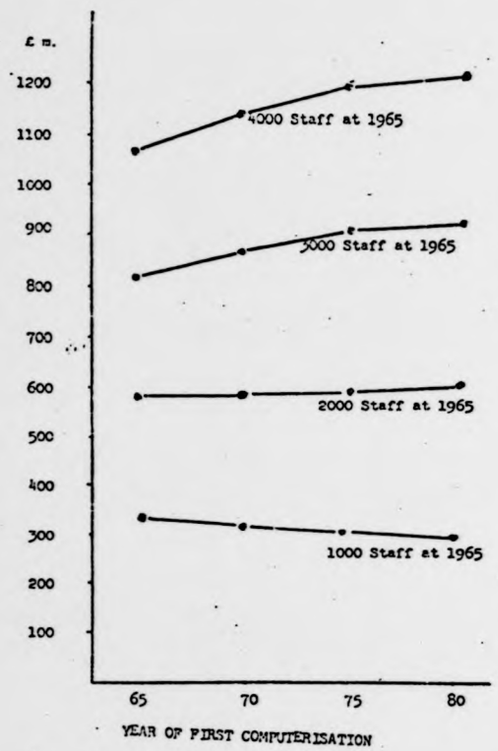
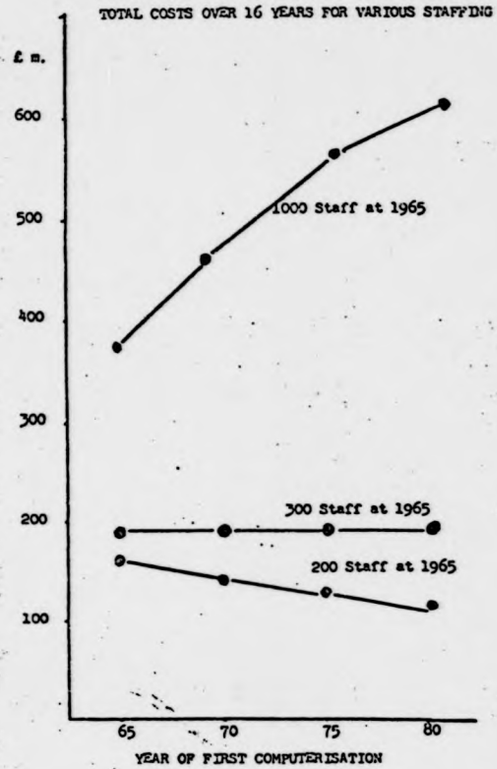


FIG 6.3 CUMULATIVE COSTS OVER 1965 - 1980 vs. YEAR OF FIRST COMPUTERISATION, AT 1980 PRICES, WITH 15% WORK GROWTH.

TOTAL COSTS OVER 16 YEARS FOR VARIOUS STAFFING LEVELS AT 1965.



Model B

The assumptions are as in MODEL A, with the exception of the first, which is replaced by the following:-

1. Throughout the term, other non-computer costs have equalled 80% of salaries, and no account is taken of rent foregone in property occupied.

TABLE 6.8 : RESULTS OF MODEL B

15% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	112 X	90 X	107
2	169 X	135 X	57
3	226 X	180 X	21
4	250 X	200 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	101 X	81 X	107
2	114 X	91 X	57
3	123 X	98 X	21
4	126 X	101 X	-

Model C

The assumptions are as in MODEL A with the exception of the seventh, which is replaced by the following:-

7. Costs are set against tax in the year of payment. Opportunity costs of property occupied represent a reduced tax liability at the same rate.

Between 1965 and 1972 company profits were taxed at various rates, tabulated in Appendix C. From 1973 to 1980 company profits were taxed at 52%.

TABLE 6.9 : RESULTS FOR MODEL C

15% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	59 X	81 X	55
2	88 X	122 X	31
3	116 X	163 X	10
4	127 X	179 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	54 X	72 X	55
2	60 X	82 X	31
3	64 X	88 X	10
4	66 X	90 X	-

Model D

The assumptions are as in MODEL B, with the exception of the seventh, which is replaced by the assumption in MODEL C.

TABLE 6.10 : RESULTS FOR MODEL D

15% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	59 X	47 X	55
2	88 X	70 X	31
3	116 X	93 X	10
4	127 X	102 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	54 X	43 X	55
2	60 X	48 X	31
3	64 X	51 X	10
4	66 X	53 X	-

Model E and Model F

Assumptions for E and F are as in A and B respectively, but with a revised computer factor as tabulated below. This change assumes that the nominal amount outlayed on computers in any year depends on the year in question. These patterns would arise if it is assumed that during the late sixties and early seventies a bank beginning a programme of computerisation would have hazarded less capital than assumed in MODELS A and B. For regimes 3 and 4, MODELS E and F produce the same result as MODELS A and B respectively.

TABLE 6.11 : Computer Factors in MODELS E and F.

Year	Regime 1	1980 Equivalent	Regime 2	1980 Equivalent	Regime 3	1980 Equivalent
65	1	4.6				
66	0.5	2.2				
67	0.5	2.2				
68	1	4.1				
69	0.5	2.0				
70	0.5	1.8	1	3.6		
71	2	6.6	0.5	1.7		
72	1	3.1	1	3.1		
73	1	2.9	2	5.8		
74	3	7.3	1	2.4		
75	2	3.9	2	3.9	3	5.8
76	2	3.4	3	5.1	2	3.4
77	3	4.4	2	2.9	2	2.9
78	2	2.7	2	2.7	3	4.1
79	2	2.3	3	3.5	2	2.3
80	3	3.0	2	2.0	2	2.0
		56		37		21

TABLE 6.12 : Results for MODEL E

15% Calculation £m

Regime	Salaries	other non-computer costs	computer costs
1	112 X	155 X	56
2	169 X	236 X	37
3	226 X	321 X	21
4	250 X	354 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	101 X	139 X	56
2	114 X	157 X	37
3	123 X	170 X	21
4	126 X	175 X	-

TABLE 6.13 : Results for MODEL F

15% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	112 X	90 X	56
2	169 X	135 X	37
3	226 X	180 X	21
4	250 X	200 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	101 X	81 X	56
2	114 X	91 X	37
3	123 X	98 X	21
4	126 X	101 X	-

Model G

The assumptions are as in MODEL A with the exception of the seventh, which is replaced by the following:-

7. Costs, other than computer costs, are set against tax in the year of payment. Opportunity costs of property occupied represent a reduced tax liability at the same rate. Outlay on computers is set against tax on a straight line depreciation basis over 7 years. Tax relief outstanding at 1980 is discounted at 12% and set against cumulative costs at 1980. Between 1965 and 1972 company profits were taxed at various rates, tabulated in Appendix C. From 1973 to 1980 company profits were taxed at 52% this rate being maintained until 1986.

TABLE 6.14 : Results for Model G

15% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	59 X	81 X	71
2	88 X	122 X	39
3	116 X	163 X	16
4	127 X	179 X	-

7% Calculation £m

Regime	Salaries	Other non-computer costs	Computer Cost
1	54 X	72 X	71
2	60 X	82 X	39
3	64 X	88 X	16
4	66 X	90 X	-

OVERALL RESULTS

For each version of the model it can be seen that there is a cross-over value of X above which a programme of computerisation undertaken at 1965 would have resulted in a lower cumulative cost over the 16 year period and below which computerisation would have been more expensive. In all cases of the model this cross-over is below 2,500 staff at 1965 for the 7% calculation and below 1,000 staff at 1965 for the 15% calculation. (See FIGS 6.4 and 6.5).

Since all three Banks (or their combined predecessors) had above 2,500 staff at 1965, and since the varied assumptions reflect the conditions within which the three Banks operated over the term, it can be concluded that computerisation involved for all three Banks a saving in cost over the 16 year period.

Since in Chapter 3 it was demonstrated that a saving in cost enhanced profits, it can be further concluded that computerisation resulted in improved profits.

The models can be used for particular staff size at '65 to give the additional cost (or saving) that would have been incurred if computerisation had been delayed till '70, '75 or '80 respectively, by finding the negative (or positive) change in total cumulative cost.

Thus, for example in MODEL A, (7%), the Royal Bank, whose predecessors had total staff of about 5,000 at '65 (this being the largest of the three) might have saved around £m 198 when all savings are accumulated, with compound interest, to 1980.

MODEL A : 7% X = 5000. Total outlay:-
Regime 1 £m 101 x 5 + 139 x 5 + 107 = £m 1307
Regime 4 £m 126 x 5 + 175 x 5 = £m 1505
Saving due to computerisation at '65 compared with no computerisation = £m (1505 - 1307) = £m 198.

The accumulated savings for the Clydesdale Bank, with staff of about 3,000 at '65 were on the basis of MODEL A (7%) possibly £m 76.

MODEL A : 7% X = 3,000. Total outlay:-
Regime 1 £m 101 x 3 + 150 x 3 + 107 = £m 827
Regime 4 £m 126 x 3 + 175 x 3 = £m 903
Saving due to computerisation at '65 compared with no computerisation = £m (903 - 827) = £m 76

That the savings should have been so significant demonstrates yet again that, as stated in Chapter 3, computerisation cannot be considered in isolation, as the three Banks though showing profit increase, do not all show improved profitability over 1970 - 1980.

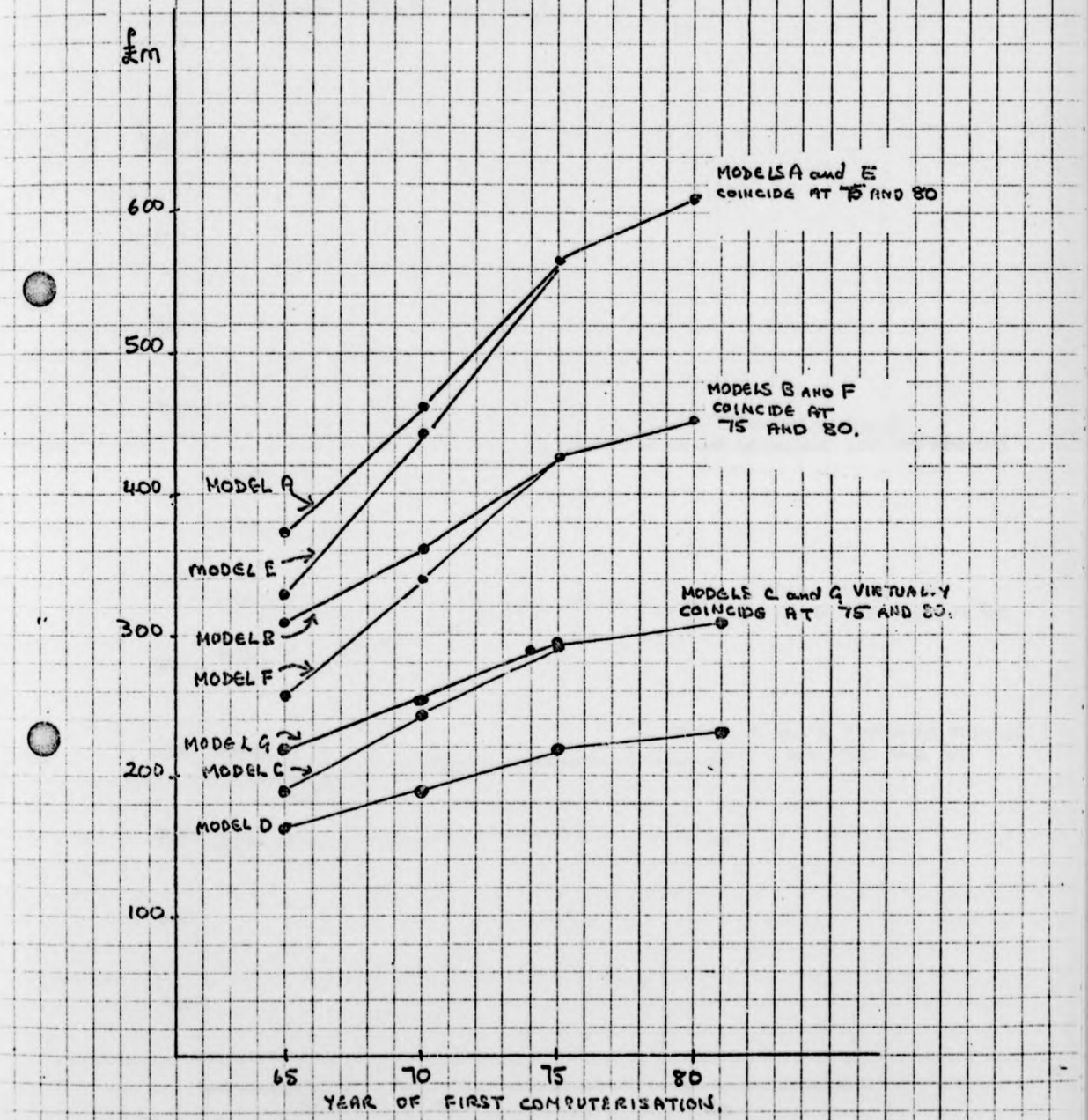
Computerisation itself is directly interactive with factors such as ruling interest rates, investment performance, and marketing approach which are among the many other factors which also affect profitability.

However, although the profit profiles of the three Banks do not immediately demonstrate improvement that can be directly attributed to computerisation, from the models above, it can be concluded that, under a wide variety of assumptions, computerisation has resulted in a significant cost saving for all three Banks.

This completes the consideration of the first two aims of the thesis.

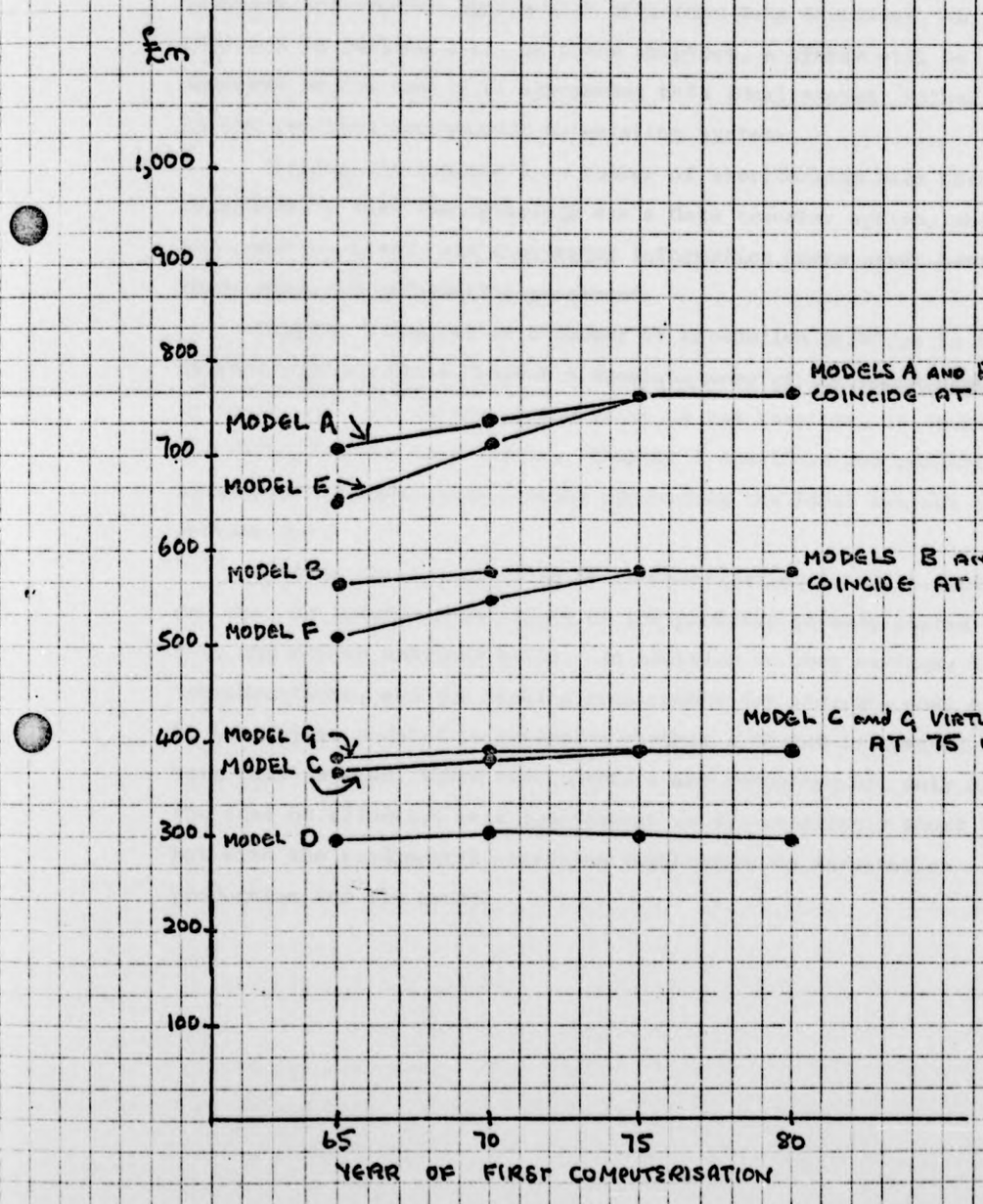
15% STAFF GROWTH UNDER NO COMPUTERISATION. FIG 6·4

CUMULATIVE COST OVER 1965-80 VS YEAR OF FIRST COMPUTERISATION AT 1980 PRICES.
1,000 STAFF AT 1965.



7% STAFF GROWTH UNDER NO COMPUTERISATION FIG 6.6.

CUMULATIVE COST OVER 1965-80 *vs* YEAR OF FIRST COMPUTERISATION AT 1980 PRICES.
2,500 STAFF AT 1965.



Chapter 7 : Clearing Production Problems

So far the thesis has been concerned with what has been done with computers in the Scottish Banks, and whether this has resulted in cost savings. Thus, the effects of computerisation have been measured against the situation in the pre-computer era. In Chapters 7, 8 and 9 the emphasis is altered. Instead of using the original system as a yardstick for developments, these chapters will consider the shortcomings of current systems against the yardstick of a Complete Information System with Efficient Data Retrieval, as outlined in Section 3.1. In these chapters, a system will be assessed by how nearly it approaches this ideal system, rather than by its relative improvement on existing systems.

Already, in Chapter 5, a number of shortcomings have been considered - that the clearings are a data transfer system, which is not computer based, and that major information users never have their required information processed.

Chapter 7 focuses on a number of production problems in the current system, while Chapter 8 examines some of the consequences of operating an information system which is not Complete, in terms of the definition in this thesis. Chapter 9 considers one possible alternative system which closely approaches the ideal set out in Section 3.1.

Whether the current mode of computerisation is still optimal can then be judged in the light of the problems already stated in 5.4, and others examined below. In addition to cost savings, time considerations, and the banking requirement for accuracy must also be taken into account in assessing whether a system is optimal. With this in mind, these next chapters are concerned not only with the idea of effective cost improvement in the relatively short term, but with the fundamental operating requirement of information production for all users.

7.1 Voucher Rejection

7.1.1 Reject re-entry systems

Attention has been drawn to the high clerical cost of clearing. In part this is due to machine rejection of vouchers. Reject experience for one Bank for a three month period ranged randomly from 6.26% to 10.30%, with month averages of 7.58%, 8.68% and 8.01%, this being calculated, in each case, as the number of cheques not captured or incompletely captured, divided by the total number of cheques to branches. These items are hand-sorted and require to be posted to the account concerned by the branch.

Before agreeing final settlement with another bank or between its own branches a bank must agree the batch total of items. Payment is made on receipt of the batch, and adjustment made at a later stage. Such adjustments can only be made when the read plus rejected items are reconciled with the original list. To do this reconciliation staff compare the list received with the batch with the list printed out by the computer. Then rejected items, identifiable by rejecting the D.C.V. with the cheques, are marked off against any differences. Any final differences are listed on reconciliation sheets and traced by audit staff. The implications of this work are discussed in Chapter 8.

Such reconciliation would be facilitated if the data on the rejected cheques were input into the computer which could then print out complete listings. However, the reader-sorter has once rejected the voucher, and is likely to do so again if a straight repeat pass is carried out. Such rejections are often due to machine-unreadable code, incomplete code or damaged cheques, or cheques in the wrong way up. One solution is to pass the cheques through medium speed sorters which display those fields that cannot be read by the machine. The operator will then key-in direct the required data, allowing the machine to list and sort. Medium speed reader sorter machines are capable of encoding. A second line of code could be printed on the cheque and the cheque then fine-sorted with a machine with two code readers set at different heights. The cost of such a reject-re-entry system is comparable with the cost of a credit inclearing system because of the extent of data keying required. With current experience of rejection, volumes are in the ratio of about 1 : 2.

The cost of such a system can be estimated by observation of the Credit Inclearing System in the Clydesdale Bank.

7.1.2 Clydesdale Bank Credit Clearing Equipment & Staffing

The Clydesdale Bank carries out its credit inclearing at its Remittance Centre in Edinburgh, using NCR equipment, as follows:-

	NO. OF ITEMS
NCR 1100 Encoders	10
NCR 7750 Workstations (Medium-Speed sorters)	4
Processors	2
Magnetic Tape units	3

For general remittance work including manual credit outclearing for the bank, and automated credit inclearing, this Centre employs:-

FULL TIME STAFF	36
PART-TIME STAFF	94

Of these it is likely that some 15 - 20 full-time staff are involved in manual credit outclearing and difference reconciliation.

Part-time staff work approximately 1/3 of a normal week. Thus the Centre employs in Remittance and Credit inclearing the equivalent of 50 full-time staff.

Credit inclearing during 1980 involved 3.7m vouchers per year. One third of all credit vouchers required to be placed in a document carrier at 1980.

Probably about the equivalent of 25 full-time staff are involved in credit inclearing. SInce these are all low grade staff the annual cost including overheads must be approximately £200,000 plus £18,000 for document carriers. Thus, per incleared voucher, excluding the cost of equipment and processor time, the Clydesdale might pay about 6p per voucher in staff costs and 0.5p in document carriers at this sorting point.

Since rejected cheques would not usually require full encoding, and would in fewer cases require document carriers, the comparable figure for a reject-re-entry system might be 3p per voucher for staff and 0.2p per voucher for document carriers. This compares favourably with the reduction that could be expected in Branch staff costs and Head Office reconciliation costs with the introduction of this kind of reject-re-entry system, as demonstrated in TABLE 7.1.

TABLE 7.1

The viability of a reject-re-entry system

Assume 60m vouchers p.a.

Assume rejection rate 8%

Number of rejected vouchers = 4.8m p.a.

Cost in reject-re-entry system

= 4.8m x 3.2p = £153,600

(See previous page for factor of 3.2p per item.)

Assume Head Office Reconciliation Staff costs consist of salaries and overheads for 8 full-time staff.

Assume 7000 Branch staff.

Assume 20% of Branch staff are occupied with voucher movement, half on voucher inclearings, and half on outclearings (based on estimate by Bankers).

Thus, the equivalent of 700 staff are occupied with voucher inclearings.

Assume 0.1 of Branch inclearing staff are saved with a reject-re-entry system (based on estimate by Bankers).

Then cost saving is equivalent to the cost of

8 + 0.1 x 700 = 78 full-time staff,

i.e. approximately £m0.7 to £m0.8.

Thus, a reject-re-entry system should allow an immediate saving in staff costs of at least £500,000 per annum, which can be used for System Design and equipment installation.

Although this suggests that there could be an immediate overall saving using a reject-re-entry system, only one Bank at the time of writing has such a system.

It must be borne in mind that this calculation gives only a rough estimate of the savings resulting from one possible systems change. In all Banks, computer systems development staff are employed in designing systems on the basis of priorities for the whole Bank. Usually systems changes are considered as part of an integrated package. Often marketing considerations influence priorities.

7.2 Clearing Deadlines : Are they necessary?

Vouchers enter the clearings during the business day and as soon as possible after the close of business. On receipt they are processed with maximum speed in order to meet clearing deadlines. Work continues during the evening and into the night in the Clearing Centres to make sure that all vouchers are processed before pre-defined times which allow for the sending of English vouchers south overnight, and the transmission within Scotland of all vouchers in the Scottish interbank clearings. Within Edinburgh, vouchers are exchanged before 12 noon on each business day. Transmission between Glasgow and Edinburgh is more flexible involving two deliveries each way, and a latest arrival time for vouchers of 12.30 p.m. If on any occasion serious delay occurs in the road transmission between Glasgow and Edinburgh, through no fault of the Banks, resulting in cheques not being received until after 2.00 p.m., normal settlement does take place, with the estimated loss of interest shared among the Banks equally. Even on peak days delays are not permitted without the agreement of authorised officials of all three Banks. It is agreed between the Banks that cheques received by them will be sent out to the appropriate branch that day.

FIG 7.1 demonstrates that there is a very considerable variation in the volumes of cheques cleared, and consequently a considerable variation in the number of man-hours of work required to process the vouchers. Banks therefore employ part-time workers, many on an on-call basis, to process the vouchers. The question arises whether some smoothing could be carried out which would enable a steady number of staff to be employed. For example, if a level staff capable of processing 115% of the average volume were retained, what proportion of the clearings would be delayed on average, and would this represent a cost? Table 7.2 sets out the experience for a three-month period expressed as a percentage above or below average. It can be seen that at 115% staffing level, no clearings need be delayed more than one day, and all of any week's work can be cleared that week. On average some 6% of clearings would be delayed on this basis.

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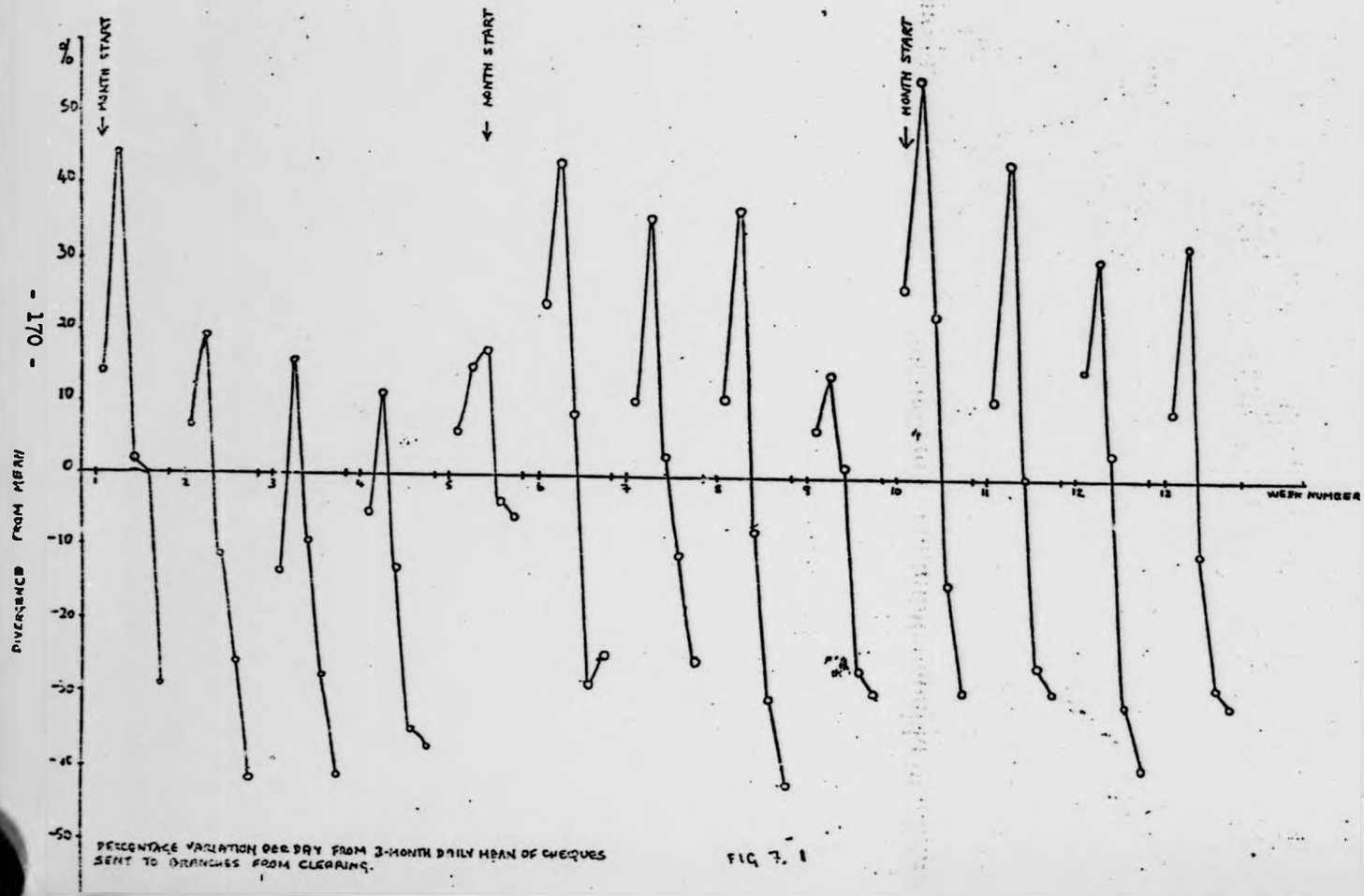

PERCENTAGE VARIATION PER DAY FROM 3-MONTH DAILY MEAN OF CHEQUES SENT TO BRANCHES FROM CLEARING.

FIG 7. 1

TABLE 7.2

Clearing Variation and Over-run at 115% average staffing level

WK NO.	VARIATION OVER AVERAGE %	OVER-RUN AT 115%	WK NO.	VARIATION	OVER-RUN	WK NO.	VARIATION	OVER-RUN
1	14.20	0	7	10.52	0	13	9.80	0
	44.55	29.55		35.90	20.90		32.87	17.87
	2.60	17.15		2.81	8.71		-10.10	0
	.28	2.43		-11.18	0		-28.41	0
	-28.63	0		-25.46	0		-31.22	0
		49.13			29.61			17.87
2	7.28	0	8	11.17	0			
	19.46	4.46		36.84	21.84		TOTAL OVER-RUN	
	-11.47	0		-7.65	0			
	-25.89	0		-30.58	0		411.72	
	-41.90	0		-41.76	0			
		4.46			21.84		AVERAGE OVER-RUN PER DAY	
3	-13.79	0	9	6.41	0			
	16.00	1.00		13.98	0			
	- 9.52	0		1.44	0		6.34%	
	-27.55	0		-26.32	0			
	-40.09	0		-29.57	0			
		1.00			0.00			
4	-4.69	0	10	26.96	11.96			
	11.39	0		55.87	52.83			
	-12.84	0		23.32	61.35			
	-34.61	0		-14.64	31.71			
	-36.92	0		-28.92	0			
		0.00			157.85			
5	6.05	0	11	13.19	0			
	14.63	0		44.41	29.41			
	16.43	1.43		0	0			
	-4.19	0		-26.03	0			
	-5.99	0		-28.92	0			
		1.43			29.41			
6	24.29	9.29	12	15.57	0.57			
	43.18	37.47		30.57	16.14			
	8.58	31.05		3.46	4.60			
	-28.99	0		-30.79	0			
	-24.23	0		-39.73	0			
		77.81			21.31			
		133.83			393.85			

OVER-RUN is the proportion of a day's work which is carried over into the next day if maximum work done is 115% of average.

The question is therefore restated as what does it cost a bank if it delays say 7.5% of its clearings by one day on average?

The Clearings can be regarded as daily positive and negative payments, resulting in a daily net payment or receipt of B. The present value of all future daily balances is Q such that

$$Q = B_o + v_d B_1 + v_d^2 B_2 + \cdots + v_d^n B_n + \text{ to infinity}$$

Where v_d is the discounting factor for one day.

If we assume that

$$B_o = B_1 = B_2 = \cdots\cdots = B_n = \text{etc.}$$

then Q is finite and equals $\frac{B_o}{(1 - v_d)}$

Since v_d is less than 1.

This is an annuity paid daily.

[It should be noted that in a stable situation the flow from any one Bank should on average equal the flow to that Bank - otherwise the Bank soon runs out of funds!]

Suppose now that the Clearings are delayed one day. Then the present value of the Clearings is the value of the annuity delayed one day

$$\text{i.e.} \qquad Q^1 = v_d Q$$

This is smaller than Q in magnitude since v_d is less than 1. Therefore the loss or gain to a Bank in deferring the Clearing settlement for one day is

$$Q(1 - v_d) \text{ i.e. } B_o$$

Thus the loss or gain to a bank for deferring 7.5% of its clearings is $0.075\ B_o$

Now only a proportion of the daily balance comes from payments to and from other banks. In-bank transfers need not affect the interest earned by the bank in total. Any marginal loss in charged interest through accounts being later in going into deficit can be recovered by an extra allowance for credit deferment, or higher overdraft interest charges. If we assume that 30% of the clearings are in-bank vouchers, then effective loss or gain reduces to

$$0.7 \times 0.075\ B_o$$

Thus, the loss or gain of interest to a Bank in delaying this proportion of the Clearings to allow for staff levelling, is

$$0.0525B_o$$

independent of the ruling rate of interest. It is equivalent to a proportion of one day's difference vanishing. It is as if the first day's balance were not settled, but every succeeding day was settled in the former way. The full effect is therefore apparent at the outset of the revised scheduling.

Suppose, for example, that B_o = £10m (e.g. daily collected or outcleared amount is £110m, and daily paid or incleared amount is £100m) then the cost to the bank for deferring this proportion of its clearings would be £525,000.

The experience of each Bank is that on average they collect less than they pay for cheques, giving a daily positive balancing figure of less than £10m. Thus, the cost in interest of a revised schedule of level staffing would be at most £525,000 for each Bank. The effect of some of this interest is transferred outside the Scottish banking system because of a net outflow of cheque payments from Scotland.

The value of meeting clearing deadlines can thus be calculated by comparing the loss of approximately half a million pounds at the outset of a revised scheduling with the discounted changes in cost of the revised staffing structure.

The saving necessary per annum at the outset depends on i the net return on funds, per annum.

Figures are not available to demonstrate that a salary cost saving would be made by re-scheduling clearings, but the required annual saving to recover a loss of £525,000 can be found using the formula

$$\text{Annual saving required} = £525{,}000i$$

It should also be remembered that a re-scheduling could actually result in a gain for a particular bank. Over all banks, the losses and gains balance to zero.

Arguably some saving would result from reduced errors if Clearing deadlines were abandoned. However, no statistics are available on the effect of rushed production on accuracy.

In conclusion it can be stated that the removal of Clearing deadlines would effectively cause a once-off charge to be incurred in respect of interest loss or gain.

This conclusion can be extended to the effects of introducing real-time accounting between Banks, so that the delay of several days in Clearing is completely removed.

The attached TABLE 7.5 indicates the time taken between receipt by a Branch from a customer and receipt by the paying Branch. These are guidelines only, and assume first class post ensures next-day delivery - a situation which does not exist.

In spite of the result above, clearing deadlines are regarded by all the Banks as sacrosanct. Thus, information production in a timely manner means, in the Clearings, meeting the clearing deadlines. While this remains the case, there will be pressure on Clearing staff to process the physical sort and complete delivery of vouchers on time.

Later in Chapter 9, an alternative solution to timely information production will be considered. Meanwhile, in the next section, the effect of these time constraints on equipment usage in the current approach will be examined.

Cheques Payable at	Day 2	Day 3	Day 4	Day 5	Day 6
1. Bank Branches	Remitted by Head Office to Drawee Branches	Received at Drawee Branch	Notice of Dishonour Received		
2. Other Scottish Banks	Delivered to Drawee Bank Head Office	Received at Drawee Branch	Notice of Dishonour Received		
3. English Clearing Banks	Remitted to Clearing Agent	Delivered to Drawee Bank and Remitted to its Branch	Received at Drawee Branch (Unless remote)	Notice of Dishonour Received	
4. London Walks Offices	Remitted to Clearing Agent	Delivered to Drawee Bank	Notice of Dishonour Received		
5. Irish Cheques and Sundries Outwith City Area	Remitted to Clearing Agent	Remitted to Drawee Bank	Received at Drawee Bank Remitted to Branch	Received at Drawee Branch	Notice of Dishonour Received
6. National Giro	Remitted to National Giro	Received at National Giro	Notice of Dishonour Received		
7. Scottish Non-Clearing					
(a) Cheques payable in Edinburgh	Delivered to Drawee Bank	Notice of Dishonour Received at Branch			
(b) Cheques Payable Elsewhere	Remitted to Drawee Bank	Received by Drawee Bank	Notice of Dishonour		

TABLE 7.5

THE CHEQUE CLEARING CYCLE

Cheques Payable at	Day 2	Day 3	Day 4	Day 5	Day 6
1. Bank Branches	Remitted by Head Office to Drawee Branches	Received at Drawee Branch	Notice of Dishonour Received		
2. Other Scottish Banks	Delivered to Drawee Bank Head Office	Received at Drawee Branch	Notice of Dishonour Received		
3. English Clearing Banks	Remitted to Clearing Agent	Delivered to Drawee Bank and Remitted to its Branch	Received at Drawee Branch (Unless remote)	Notice of Dishonour Received	
4. London Walks Offices	Remitted to Clearing Agent	Delivered to Drawee Bank	Notice of Dishonour Received		
5. Irish Cheques and Sundries Outwith City Area	Remitted to Clearing Agent	Remitted to Drawee Bank	Received at Drawee Bank Remitted to Branch	Received at Drawee Branch	Notice of Dishonour Received
6. National Giro	Remitted to National Giro	Received at National Giro	Notice of Dishonour Received		
7. Scottish Non-Clearing					
(a) Cheques payable in Edinburgh	Delivered to Drawee Bank	Notice of Dishonour Received at Branch			
(b) Cheques Payable Elsewhere	Remitted to Drawee Bank	Received by Drawee Bank	Notice of Dishonour		

TABLE 7.5

THE CHEQUE CLEARING CYCLE

7.3 Future Clearing volumes and the Effect on Equipment Usage

Unless there exists the intention to revise a process with changing volumes and technology, whenever volumes of throughput are increasing the question arises as to when current capacity will be over-reached, and whether suitable additions can be made to capacity to accommodate such increases. In the case of computerised equipment these considerations must be made well in advance because there can be considerable lead-times for the delivery of equipment, followed by long commissioning delays while software is fully tested and any problems in operation overcome. Thus it is necessary to be aware of likely volumes several years ahead.

These considerations are particularly important with regard to reader-sorters, as these form the main area at which process delays occur. Because of the duplication of computers themselves to cover the contingency of full processor failure, the computational and buffer capacities of computers used in retail banking are well above likely work volumes in the next five years (although spare capacity is used for additional non-essential customer services). Thus, in this section the reader-sorter constraints alone will be examined.

Tables 3.13 and 3.14 list past volumes in each Bank of clearings. Debit inclearing and Credit outclearing will be considered here. These are used because the longest and most reliable runs of data are available for these types. Debit outclearing follows the pattern of inclearing very closely, while credit inclearing is the smallest element, in voucher-volume terms, of the paper clearings. On the assumptions stated it is seen that volume growth over the five years to 1985 is likely to range from 40% to 75% in the case of debit inclearings and 20% to 55% in the case of credit outclearings. Peak volumes are likely to increase at the same rate.

Fast reader-sorters currently in use are, according to specifications, able to process 1,200 documents per minute. However, specifications are seldom met because of voucher imperfections, system jams or machine malfunction, each type of delay associated with the mechanical and human-operated nature of the equipment. Thus, an efficiency ratio must be introduced to any calculations of required lapsed machine time for document processing.

Sort-time does not start until sufficient keyed documents are received, and there are some five hours then available in the evening in order to meet the deadline for the London outclearings, these being the first bundles which must be outcleared.

The second dead-line is for other Scottish Banks, and occurs in the mornings. Thereafter, the working day is available for processing inclearing vouchers for remitting to Branches, and for the evening account update. The critical time availability is for the London clearings. All machine printing and bundle packing must be completed before the job can be considered complete. The data processing takes only a fraction of the document sorting time, and therefore the constraint is in voucher packing. A machine can sort a particular bundle into sufficient different pockets for the major London Banks. Additional runs are required to sort into finer form for the minor and sundry banks.

Calculations assume that the fine-sort is minimal in comparison to a 2 : 1 allowance for machine inefficiency (and could in fact be considered as part of this allowance).

The number of machines required to process annual volumes can be estimated.

Annual Volume	= K
Peak to average ratio	= 1.6
No. of working days	= 250
Process speed	= 1200 per minute
	= 60 x 1200 per hour
Inefficiency ratio	= 1/2
Available process hours	= 5

Then number of machine hours required is

$$\frac{\text{Annual volume} \times \text{Peak to average ratio}}{\text{No. of working days} \times \text{Process speed per hour} \times \text{Inefficiency ratio}}$$

$$= \frac{K \times 1.6}{250 \times 60 \times 1200 \times (1/2)}$$

$$= K\,10^{-6} \times (0.18)$$

Hence the number of machines needed for annual volume K to meet dead-lines is

$$N = \frac{K\,10^{-6} \times (0.18)}{5}$$

To determine required numbers of machines in the next five years, it is necessary to estimate future volumes, as in TABLE 7.6.

Hence ranges for numbers of machines required are as follows:

TABLE 7.7

Annual Volume of Vouchers (millions)	No. of fast reader-sorters
0 - 28m	1
28m - 56m	2
56m - 83m	3
83m - 111m	4
111m - 139m	5

The actual change-over points for bringing in new sorters is vague, partly because of the variation in peak volumes, and partly because the cost of new machines must be set against the cost of missing deadlines, which, for each event, can be of the order of £100 (1980 prices), as it involves the cost of a senior staff member transporting the London clearings via Scotland-London late evening train. However, missing the flight incurs interest-loss through settlement delays.

On the assumptions therefore, the total requirements for fast-reader sorters would be as follows:-

TABLE 7.8

	RBS		B of S		C.B.	
	BASIS	BASIS	BASIS	BASIS	BASIS	BASIS
YEAR	1	2	1	2	1	2
81	3	3	3	3	2	2
82	3	3	3	3	3	3
83	3	3	3	3	3	3
84	3	3	4	4	3	3
85	4	3	4	4	4	3

On no projection considered would more than one fast reader-sorter be required by any Bank for credit outclearing.

Advanced high-speed sorters can, however, be programmed and set to read at twice the speed assumed, and this new generation of reader-sorter is likely to be brought in as volumes increase.

On the alternative automated credit system involving medium speed sorters, the requirement for encoders and medium-speed sorters by each Bank can similarly be estimated.

Medium-speed sorters operate at around 200 documents per minute. Thus, some 6 times the number of reader-sorters are required for the same volumes. Cross-overs are as tabulated.

TABLE 7.9

Credit Voucher Volumes (Millions)	Total Required No. of medium-speed reader-sorters
0 - 4.6	1
4.6 - 9.3	2
9.3 - 13.9	3
13.9 - 18.5	4

TABLE 7.10 No. of sorters required in total by Banks for Credit Clearing (Medium-speed)

	RBS		B of S		C.B.	
	(1)	(2)	(1)	(2)	(1)	(2)
81	3	3	3	3	3	3
82	3	3	3	3	3	3
83	3	3	3	3	3	3
84	3	3	4	4	3	3
85	3	3	4	4	4	3

It can be concluded that, while the physical sort determines the time required to process clearings, sustained investment in reader-sorter equipment will be required in each Bank. Growth in volumes will also necessitate enlarged premises for sorting.

These production constraints will remain while paper is the basis for data transfer.

Current systems have in addition a far more fundamental problem - that of data corruption. This is examined in detail in Chapter 8, in the light of the criteria for information systems discussed in Chapter 3. The importance of the problem of data corruption is due to the premium the banks traditionally place on accuracy.

TABLE 7.6

FUTURE CLEARING VOLUMES : NEXT FIVE YEARS 81 - 85
MILLIONS OF ITEMS

DEBIT : BASES (1) AVERAGE GROWTH MAINTAINED.
INCLEARING (2) AVERAGE GROWTH 2% LESS PER ANNUM.

	RBS		B of S		C.B.	
YEAR	BASIS (1)	BASIS (2)	BASIS (1)	BASIS (2)	BASIS (1)	BASIS (2)
81	61.7	60.6	66.9	65.7	53.7	52.7
82	67.6	65.2	74.2	71.5	59.9	57.8
83	74.0	70.1	82.4	77.9	66.9	63.3
84	81.1	75.5	91.3	84.8	74.7	69.4
85	88.9	81.2	101.3	92.4	83.4	76.1
GROSS INCREASE % OVER FIVE YEARS						
	58%	44%	68%	53%	73%	58%

CREDIT : BASIS (1) AVERAGE GROWTH MAINTAINED
OUTCLEARING (2) AVERAGE GROWTH 2% LESS PER ANNUM.

	RBS		B of S		C.B.	
YEAR	BASIS (1)	BASIS (2)	BASIS (1)	BASIS (2)	BASIS (1)	BASIS (2)
81	8.5	8.3	10.7	16.5	10.2	10.0
82	9.1	8.8	11.9	11.5	10.9	10.5
83	9.8	9.2	13.3	12.6	11.6	11.0
84	10.5	9.7	14.8	13.8	12.4	11.5
85	11.2	10.2	16.5	15.1	13.2	12.0
GROSS INCREASE % OVER FIVE YEARS						
	31%	23%	54%	44%	30%	20%

Chapter 7 : Notes & Bibliography

1. "The Scottish Debit Clearing" - Agreement between the Scottish Clearing Banks on the rules and regulations of the Debit Clearings in Scotland. Draft. September 1980.

2. Notes on FIG 7.1.

The pattern of cheques cleared out to branches could be described in terms of superimposed waves of different wave lengths:-

* short wave length of one week (largest amplitude)
* medium wave length of one month (medium amplitude)
* long wave length of one year (small amplitude)

The greatest observed Clearing is at the coincidence of the monthly, weekly and annual peaks.

Weekly clearing peaks occur on Tuesdays (debit).

Monthly clearing peaks occur at month start (debit).

Credit clearings follow a similar pattern with more variation between month-ends and mid-month dates. Credits and cheques peak at slightly different times.

Chapter 8 : Clearing Differences

It was stated in Chapter 6 that the listings of cheque bundles produced by the computer during automatic sorting, did not in fact accurately describe the bundles of cheques sorted by the machine. Up to one quarter of the lists can be wrong in some respect. This occurs both at the outclearing and at the inclearing stages. These Clearing Differences are a significant and expensive problem, not only involving a considerable proportion of branch time, and requiring a Head Office department of around thirty staff, but also being potentially very damaging to customer relations.

There are some hundreds of these differences in each Bank every day, whereas in the electronic funds transfer systems operated by the Banks, and each involving in volume of transfer about one tenth of the volume of cheques cleared, one difference may occur every few months. Thus, clearing differences are a problem peculiar to the paper-based clearings. By showing the nature of the differences, this chapter seeks to demonstrate that it is the paper-based nature of the retail information systems of the Banks which is itself the major cause of Clearing Differences. These result from inadequate validation of input data, the introduction of errors by automatic sorting machinery, and the loss, destruction, or introduction of vouchers during the sorting and transmission process. Difference reconciliation is hampered by inadequate indexing of data in Clearings, and the fact that no complete base of data is maintained by any Bank for reconstruction of clearing listings. These differences are not due to technical errors, which cause the return of the voucher. Nor are they due to machine rejection, which is corrected by manual sort. Errors in Clearing can arise from the point of entry to the Clearing, until the point of exit from the Clearing - i.e. from the time of cheque writing until the time of packing in envelopes to send to customers. However, relevant Clearing errors in terms of this study do not originate after the receipt of the voucher has been acknowledged by the branch.

The vouchers remain throughout the system the ultimate file of clearing data. Because current systems never remove all data from the vouchers, the vouchers themselves, or a copy of them, are an essential part of the base of data of the Banks.

Yet, only in one of the Scottish Banks (the Clydesdale) is any attempt made to retain a copy of every voucher that enters the information system. The technical inadequacies of microfilm, however, prevent complete success. Both the other Banks microfilm only hand-sorted cheques. When Reconciliation Departments search for a voucher they are not able to produce a copy in every case. Thus, no Bank currently has a Complete Information System as defined in Chapter 3, as some differences can never be removed. The system is therefore out of control, as the exit of a voucher from the system implies that the information produced by the system cannot be reconstructed.

It would perhaps be cheaper to accept the incomplete nature of the information system and write-off losses resulting from differences rather than set up a Complete Information System. However, the value of the daily differences is random, varying up to plus or minus 10% of the day's clearings. Most of this is corrected within a very short time, but a residue of the order of thousands of pounds requires considerable searching to resolve. Auditors would be unlikely to accept this order of daily difference. In addition, in banking, a very high premium is set on accuracy. To ensure accuracy, a complete base of data is necessary. Only the Clydesdale Bank is close to having a complete base of data on file, and this file is not in a suitable form for efficient (see Glossary) data retrieval. Thus, where it is possible, error correction is expensive.

Most errors not corrected during clearing itself can be found and corrected within a few days. However, some differences are never removed (although virtually full information of the voucher is available) because no copy of the voucher is located and hence no absolute agreement can be reached on the correct version. Such remaining differences are eventually written off.

Thus, it is in the interests of all Banks to develop a system in which

a) differences are identified quickly,

b) branches are informed on the same day of relevant vouchers to be retained for difference reconciliation.

More appropriate would be, in fact, to establish a system which was not error prone, and in default of that, to establish a complete base of data in a reliable form - such as full imaging of all vouchers in a machine-indexed file using Image Processing.

8.1 The Origin of Differences

In the current system, for each batch of vouchers that is received at the Clearing Department, and passed through a reader-sorter, there are two lists - the outclearing list received with the bundle, and the "received" list produced by the reader-sorter. The differences between these listings constitute the core of the Clearing Differences.

The difference in total, positive or negative, is taken to a Reconciliation Account, and the components of this difference, positive or negative, form a list of individual errors of a number of types, such as:-

missing voucher
extra voucher
difference in amount (misread or error) of voucher
voucher listed twice (read twice by reader sorter)
mis-sort (voucher belongs to another batch)
invalid bank/branch/account
other difference not accounted for.

8.1.1 The Particular Sources of Differences.

The first source of Clearing error is in the printing of the codeline on a cheque before it is issued to a customer. A cheque before issue should be fully PERSONALISED - i.e. it should have printed onto it, in ordinary ink, the customer account name, the branch name and address, and the branch sort code number. In addition, in MICR it should have the cheque serial number, the bank and branch sort code number and the account number. The serial number is an accounting, and not a Clearing, field. However, the absence of either of the other two MICR encoded fields renders a cheque unsortable by machine. If in addition the ordinary ink account data is missing, the cheque cannot be manually sorted. Thus, for such a situation all that is known about the origin of the cheque is that it has come from the Bank, signed by someone who may or may not be a genuine customer of the Bank. However, if it is a genuine cheque it will be paid by the Bank, and the amount in question posted to the Clearing Differences Account. If no branch code is available then there begins a search throughout branches for recognition of the signature, and thus identification of the account to be debited.

. Such an error, (included in the category "invalid branch/account") is a result of production imperfection at cheque printing not detected by branch staff before issue of a cheque book, or by issue in error of a non-coded non-identified "counter" cheque by branch staff. All cheques issued to customers should be checked for correct encoding and printing before issue. Thus such errors are attributable to human fault, either independently or following printing production faults.

The incidence of such errors is low - of the order of one or fewer cheques per month per Bank.

The second stage at which error can enter the system is at the outlisting of cheques from a branch to its head office. Batches of cheques can be manually or machine add-listed, and a total figure reached. Encoding follows, either in branch or encoding centre. The encoding machine impresses an MICR figure on a voucher. Amounts are totalled by the machine. This batch total is compared with the total listed by the branch, and differences are found. Some 10% to 20% of batches will show a difference. These differences are located and corrected, either on the branch or MICR list. Correction on the MICR list involves identifying the voucher, erasing the incorrect amount and re-encoding, along with the correction of the MICR total which is the amount entered on a clearing D.C.V. The omission of both these correcting procedures will cause an error which cannot be detected until the manual check on receipt at the branch. Omission of one of these two correcting procedures causes a clearing difference. Such a difference will be identified as a MIS-READ.

MICR encoding machines are electromechanical devices, and so are themselves capable of introducing errors to the system. The machine can fail to encode, while including the amount in the total. It can encode a different amount from the amount totalled [a MISCAST]. It can encode too heavily, causing embossing. It can encode unevenly, causing machine misread [e.g. 8 instead of 3]. It can also produce "reject" conditions by encoding in a blurred or over-heavy manner. Rejects are not relevant to Clearing Differences, because they are located in the manual sort. However, the level of rejection affects the ease or otherwise of locating Clearing Differences.

From the list stage onwards the MISSING or EXTRA conditions can enter the system. In order to reflect listings bundles must be kept intact and preferably in the same order.

In sorting machines bundles are separated by DCV's, and human error, particularly in the situation of machine jam or malfunction, can misplace the DCV. This causes complementary MISSING and EXTRA conditions in adjacent batches. However, not all MISSING and EXTRA conditions come in pairs. The electromechanical nature of reader-sorter machines again causes imperfections in the sort system. It is possible for a voucher to be carried through the machine on the back of another. In outclearing this represents a lost voucher. In inclearing it reappears as an extra voucher. Throughout all banks such conditions should pair. However, the pick-a-back condition happening in the second stage (inclearing) causes a MISSING situation only. It is possible for a voucher to be jammed somewhere in the machine and be released later. Usually this will stop operation and the operator resets the relevant vouchers. However, this is not always the case, causing more MISSING and EXTRA conditions. Finally, if a bundle of vouchers is dropped and scattered at any point in the clearing the result is that vouchers can be physically lost. Most missing items are found in branches on checking the vouchers sent to them from Clearing. If the voucher relates to the branch it is retained and accounting details sent to head office and Clearing Differences Department. Otherwise the voucher is returned and re-routed. Vouchers can be physically destroyed. This is a rare event, but not non-existent. The reader-sorter itself can destroy vouchers, as well as other mishaps. Upside-down vouchers cause REJECT but no difference.

System jam was mentioned above. This can cause the additional error condition of READ-TWICE. Jam can be caused by reader-sorter malfunction, or by crumpled or damaged vouchers, or by vouchers containing pins, paper clips, and so on. Operators are instructed to place any unsuitable vouchers in special voucher carriers, which allow the voucher to be seen, and coding to be read. This is not always done. Branch staff are instructed to remove pins etc. from vouchers before remitting them to Clearing. This is not always done. Perforations should be removed from vouchers. Again, there is room for human error. Systems are designed so that when a sort is restarted after a system jam the computer should be able to identify which vouchers have already been read. For this purpose the buffer in the reader-sorter retains the code-line of the last twenty or so items read (depending on bank).

The incidence of the READ-TWICE condition suggests that this amount of retention is inadequate. However, another explanation is that on restart the DCV is misplaced causing the machine to fail to recognise the voucher because it now appears to be from a different batch. The Read-twice condition can also arise if at a jam a voucher has been read, and on being fed in the second time it is rejected, and listed with the manual sort. System jams can also cause vouchers to go missing.

Some differences are not identified. Perhaps one or two batches in each Bank per day will not be balanced to the extent of a few pence. In accounting terms such difference should never exist. It should always be possible to identify items in two lists which are different causing the full overall difference. However, the Banks tolerate some "unaccountable differences". Existing non-paper systems, such as the direct debit system, do not exhibit such differences. System errors and mechanical breakdowns can occur, but the incidence is negligible compared with the daily paper clearing differences.

Manually sorted vouchers reaching branches unlisted are identified to Head Office. Incorrect identification of these items introduces further differences. Such misinforming of accounting data is due in the main to keying error at terminals, or listing error in data input sheets.

8.1.2 Comment

From the above it can be inferred that the vast majority of Clearing Differences arise either from human error, or electro-mechanical fault. Only a very small proportion arise from System inadequacy, and this inadequacy is attributable to the automated nature of the Clearing - it is due to the difficulty in recognising paper which the machine has previously encountered. No systems differences arise out of the data processing. The existence of errors in the paper clearings can thus be attributed directly to the paper-based nature of these clearings.

In contrast to the paper clearings, no reconciliation departments are necessary to correct the fully computerised clearings which offer direct debiting, direct crediting and automatic standing order services in-bank and through BACS. The difference between the two clearing systems lies not in the data processing (which is virtually identical in both) but in the fact that paper sorting exists in one and not in the other.

8.2 Clearing Difference Volumes

Analysis of the differences experience of the Banks suggests that in number this varies greatly. However, it can generally be concluded that the majority of differences arise from missing cheques, extra cheques, and cheques for which the amount is in dispute, either through a machine misread, or through a keying error. (see APPENDIX G)

In considering the growth of volumes of differences, these three conditions and their correction must be examined.

Assuming that encoding standards do not further deteriorate, it is likely that the total number of cheque amount differences will be directly proportional to the total volume of clearing.

i.e. if V = volume

and k = proportion of vouchers with disputed value

then $M = kV$ where M is the total number of such differences.

However, vouchers are missing or extra because of a number of factors, human and machine. The number of such errors can intuitively be expected to increase with volume, more than in strict proportion to the total volume of vouchers. Assuming a best case of direct proportionality with relative constant e, then

$$E = eV$$

where E is the total number of missing and extra vouchers.

The time, t, to correct any error will depend in some way on the total volume of clearing

i.e. $t = rV^a$ where $a > 0$

This is so because as volumes increase, the search time at each stage in the audit trail must increase, simply because there are more items to search through.

The total time T for difference reconciliation is $t(M + E)$, this being the total number of errors times the correction time per error.

i.e. $$T = t(M+E)$$
$$= rV^a(kV + eV)$$
$$= r(k + e)V^{1+a}$$

So T is proportional to V^{1+a} where a is greater than zero.

For this reason it is essential that, if the current paper clearings remain,

1. differences are reduced in volume and/or
2. the audit trail is computerised.

The samples in APPENDIX G represent the experience in inclearings, and in outclearings, and although showing considerable variation, demonstrate that the problem is extensive. Sets of samples are for comparable clearings at inclearing and outclearing stages, the data having been extracted from difference schedules.

The frequency of difference types within individual batches follows a pattern similar to a Binomial distribution, with the binomial parameter independent of batch size, and determined by batch source. There does appear, though, to be a higher likelihood of more than one difference than would be expected if difference conditions were fully independent (see FIG 8.1).

8.3 The Procedure of Difference Reconciliations : Debit Clearings

The details of the procedure for difference reconciliation depend on the extent to which terminals are used to inform the accounting system of errors discovered at branches and of cheques found at branches not listed in inclearing schedules.

However, the general approach has three parts:

1) identify differences, suggest reasons for the difference, and prepare reconciliation schedules
2) identify errors discovered at branches and other banks, and match these with the relevant differences. At the same time, trace relevant vouchers to establish correct data, though without recalling vouchers to Head Office.
3) reverse out wrong entries, enter correct entries to accounting system and correct payments due to and from other banks.

Part 1 is carried out by a number of staff who compare the lists provided with batches by outclearing banks with the list read by the computer plus the list of rejected cheques. From this comparison are prepared Reconciliation sheets, containing the following for each difference:-

The batch number
The supposed batch total
The read batch total plus the total of rejects
The name of the outclearing bank
The components of the total difference
The supposed source of difference

MISSING ITEMS

200 BATCHES, 50,000 ITEMS
36 HAD MISSING ITEMS
48 ITEMS MISSING

BINOMIAL DISTRIBUTION
$n = 250$
$p = 0.00096$

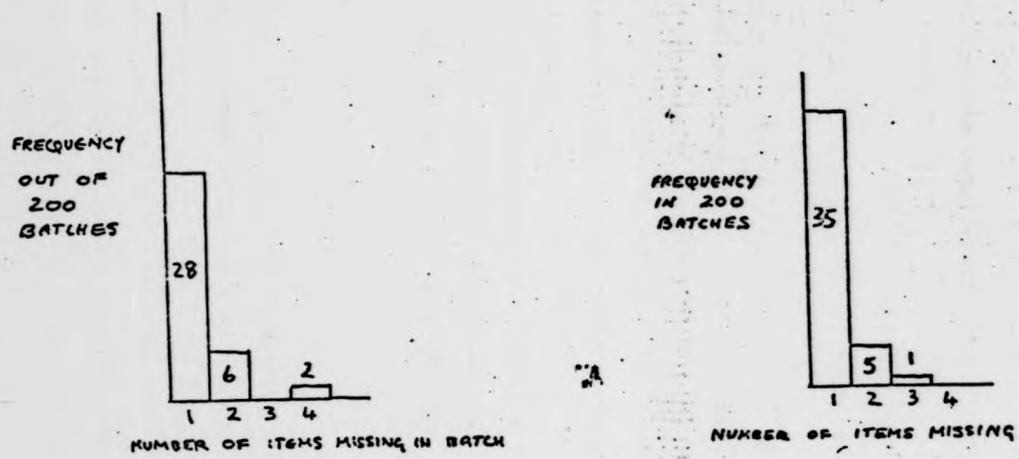

FIG 8.1 COMPARISON BETWEEN ONE BATCH OF MISSING ITEMS AND BINOMIAL DISTRIBUTION.

These components of the total difference are amounts along with as much detail as is known, for example missing values (for which only the value is known) and also, extra values, or amount difference values, along with the bank sort code, account number and serial number.

In addition, the sheet provides space for the net effect of the difference component, either credit or debit, and columns for the correct figure when it has been identified, with room also for a date of correction.

These schedules form the working base for the Reconciliation staff.

Reconciliation schedules are currently manually prepared and are not available until as much as several days after the relevant clearings, by which time vouchers may have left the branches.

8.3.1 Computers in Difference Reconciliation

In assessing how far the use of computers can overcome the problems of Clearing Differences it must be emphasised that the crucial factor is the fact that no complete base of data is maintained. The principal advantage of computerisation is therefore that its speed can to an extent overcome this deficiency, by allowing identification of most vouchers relevant to Clearing Differences before they are dispersed. The computer could produce lists of differences on the same day as Clearing, and alert branch staff to relevant vouchers, so that copies could be made to allow reconciliation to be carried out in a considerably improved proportion of cases.

However, the preparation of Reconciliation Schedules cannot currently be done by the computer because the computer does not have in it all the data necessary - in particular the computer does not have on its files the lists which accompany the bundles of items received by Clearing departments. In addition, the absence of a full reject-re-entry system means that, even on the incleared list, not all records are available to the computer for it to make the comparison. Thus computerisation of Reconciliation schedules pre-supposes the presence of a reject-re-entry scheme.

In order for preparation of Reconciliation Schedules to be done by the computer outclearing lists have to be input. This can be done in one of three ways, or a combination:

1. By direct duplicate keying of the data on the lists.
2. By OCR uplift of the data on the lists.
3. By receipt of magnetic media data from delivering offices.

Of these, the first is in fact the least attractive, because, on the basis of 200,000 items per day, and 10,000 key depressions an hour by an operator with an average of 4 depressions per voucher there would be no net staff saving at this part of the audit, and in fact, for low difference rates, a high net cost.

Both of the other two methods could be attractive, particularly when it is considered that a large proportion of clearing is, in fact, inter-branch - the proportion depending on the market share held by the bank. (3) is by far the most attractive, as it is possible for encoding machines to prepare magnetic lists as they are encoding, and for fast reader sorter systems to produce tape listings.

Input method (3) has the further advantage that it is a useful jumping-off point for computerisation of the whole inter-bank audit trail. At the present time difference tracing and error reversal is carried out through a succession of non-integrated computer and non-computer stages e.g. cheques manually remitted are processed by computer for sending manually to another bank, where again they are processed by computer, and errors are identified manually at branches. Associated vouchers from the same transaction have no genuine computerised tie-up. The audit trail requires tracing a voucher through this clearing, and error reversal requires entry and exit from data processing systems at different stages, increasing the tendency to introduce further errors. Fully integrated inter-bank clearing systems would, quite apart from the possibility of reducing differences, reduce the work involved in difference reconciliation. Those banks with automated Random Remittance of vouchers are in a good position to prepare tapes for exchange along with batches of cheques. All three Scottish Banks, therefore, could take part in such an exchange system. Table 8.1 demonstrates that a very high proportion of Clearings would indeed be amenable to tape exchange, as the vast majority of clearings from outside the Scottish Banks come from the London Clearers.

For residual batches not covered by magnetic listing - i.e. from sundry banks with no Random Remittance System - OCR or key-to-disc input are both acceptable, the latter probably at the current time being more reliable. The volumes of sundry clearing items would imply an acceptably low level of such keying activity.

Magnetic tape lists, delivered either as a tape or over a data communications line would contain full code-line details of each cheque - i.e. bank sort-code, account number, serial number and amount. This could then be compared directly with the uplifted data from incleared bundles of cheques, and could be used to produce Reconciliation sheets with enhanced information content: i.e. missing cheques would now be listed with full accounting information, rather than simply the missing amount.

8.3.2 Difference Identification by computer

Where tape exchange is agreed, all difference types would readily be identifiable by a straightforward comparison of the full codelines for each item. Reconciliation schedules could therefore be produced as at present. This system would involve relatively little analysis and programming time, plus a regular annual cost of actual tape exchange, and would considerably reduce the time involved in preparing Reconciliation schedules (currently carried out by 6 to 10 staff, depending on Bank) particularly if it is set up after the installation of a reject-re-entry system, such as was discussed in the previous chapter.

Where tape exchange is not agreed it is still possible to identify the error types and prepare Reconciliation schedules on computer using only the list of amounts provided with the batch by the outclearing bank, with no loss on present accuracy. (Contrary to the opinion of some Clearing managers.)

Some error conditions are readily identifiable:

1. invalid Bank
2. invalid Branch
3. invalid amount
4. invalid account number
5. read twice, three times etc.

These do not require the other bank list, although this is required in order to identify the correct amount to be paid for the batch.

The remaining errors are of the form:

6. missing
7. over
8. dispute in amount

It is possible to demonstrate that with the error experience of the Banks, differences can be separated into appropriate types with a very high level of reliability, using the tests outlined in the flowchart, FIG 8.2

For these tests several definitions are necessary:

MISPUNCH - ONE DIGIT DIFFERENCE IN AMOUNTS

INVERSION - TWO ADJACENT DIGITS ARE INVERTED, OR TWO SEPARATED BY ANOTHER DIGIT ARE INVERTED

TRANSLATION - THE COMPLETE SEQUENCE OF DIGITS IS MOVED ONE OR TWO SPACES TO THE LEFT OR RIGHT.

It is supposed that the two lists will be compared, and unmatched items will go into an "unpaired pool". This pool has two sides - the records of items not read on the bundle of vouchers but

on the outclearing list, and the records read but not on the outclearing list. Each value on one side of the pool is compared with values on the other side until it is matched as a difference type, or unmatched with all values.

Thus, the computer can produce Reconciliation sheets which contain no less information than the current manually prepared sheets. The Statistical justification for believing that there would be no loss of accuracy on the manual method is set out in APPENDIX F.

DEBIT CLEARING — MILLIONS OF ITEMS — TABLE 8.1

1980 FROM \ TO	RBS	B of S	C.B.	Others	Total
RBS	16.3	17.9	10.8	13.6	58.6
B of S	11.3	14.4	7.9	13.3	46.9
CB	8.8	9.0	10.7	26.7	55.2
Others	19.9	19.7	18.7	0	58.3
Totals	56.3	61.0	48.1	53.6	219.0

1979 FROM \ TO	RBS	B of S	C.B.	Others	Total
RBS	14.7	15.9	9.7	13.5	53.8
B of S	10.6	13.2	7.0	13.2	44.0
CB	8.2	8.4	9.5	23.1	49.2
Others	16.8	16.9	16.7	0	50.4
Totals	50.3	54.4	42.9	49.8	197.4

1978 FROM \ TO	RBS	B of S	C.B.	Others	Total
RBS	12.5	14.3	8.8	13.4	49.0
B of S	9.6	11.9	6.9	11.9	40.3
CB	5.9	5.5	7.6	24.0	43.0
Others	13.6	16.4	14.9	0	44.9
Totals	41.6	48.1	38.2	49.3	177.2

TESTS TO DETERMINE WHETHER AN EXTRA VALUE AND A MISSING VALUE ARE RELATED BY A MISREAD CONDITION

Let larger value = X
Let smaller value = Y

Number digits as A,BCD,EFG.HJ where these can take values 0 - 9 inclusive.
Compare corresponding digits in X and Y.

(1) There is only one digit different - then MISPUNCH — TEST 1
There is more than one digit different - then further tests.

(2) Two digits different - this may be an inversion. Inversion is allowed if two adjacent digits are inverted (1st order) or if two digits separated by one other are inverted (2nd order).
Identify the digits which differ. Invert them. Compare the two numbers — TEST 2
If the numbers X and Y are now the same, then INVERSION
If not, then further tests.

Calculate $\frac{X - Y}{9}$

$= Q + R_1$

Q is the quotient and R_1 is the remainder.

(3) Two digits different and not inversion, or more than two digits different.
A translation or partial translation is being investigated.

If $R_1 \neq 0$ then NO RELATION — TEST 3A
If $R_1 = 0$ then further tests.
If $R_1 = 0$ and $Q = Y$ then 1st ORDER TRANSLATION — TEST 3B
If $R_1 = 0$ and $Q \neq Y$ then further tests.

Calculate $Q/11 = K + R_2$

(4) If $R_2 \neq 0$ then NO RELATION — TEST 4
If $R_2 = 0$ and $K = Y$ then 2nd ORDER TRANSLATION
If $R_2 = 0$ and $K \neq Y$ then no full translation condition holds. Further tests.

(5) Does the difference X - Y end in a string of zeros ? — TEST 5
NO - then NO RELATION
YES - then partial translation possible - further tests.

Calculate Y - Q = S

P = 10 x Q + S

T = Y - K

L = 100 x Q + T

(6) Compare X and P.
If they are the same i.e. X = P then 1st order PARTIAL TRANSLATION — TEST 6
If $X \neq P$ then final test.

(7) Compare X and L. — TEST 7
If X = L then 2nd order PARTIAL TRANSLATION
If $X \neq L$ then NO RELATION.

TESTS ENDED.

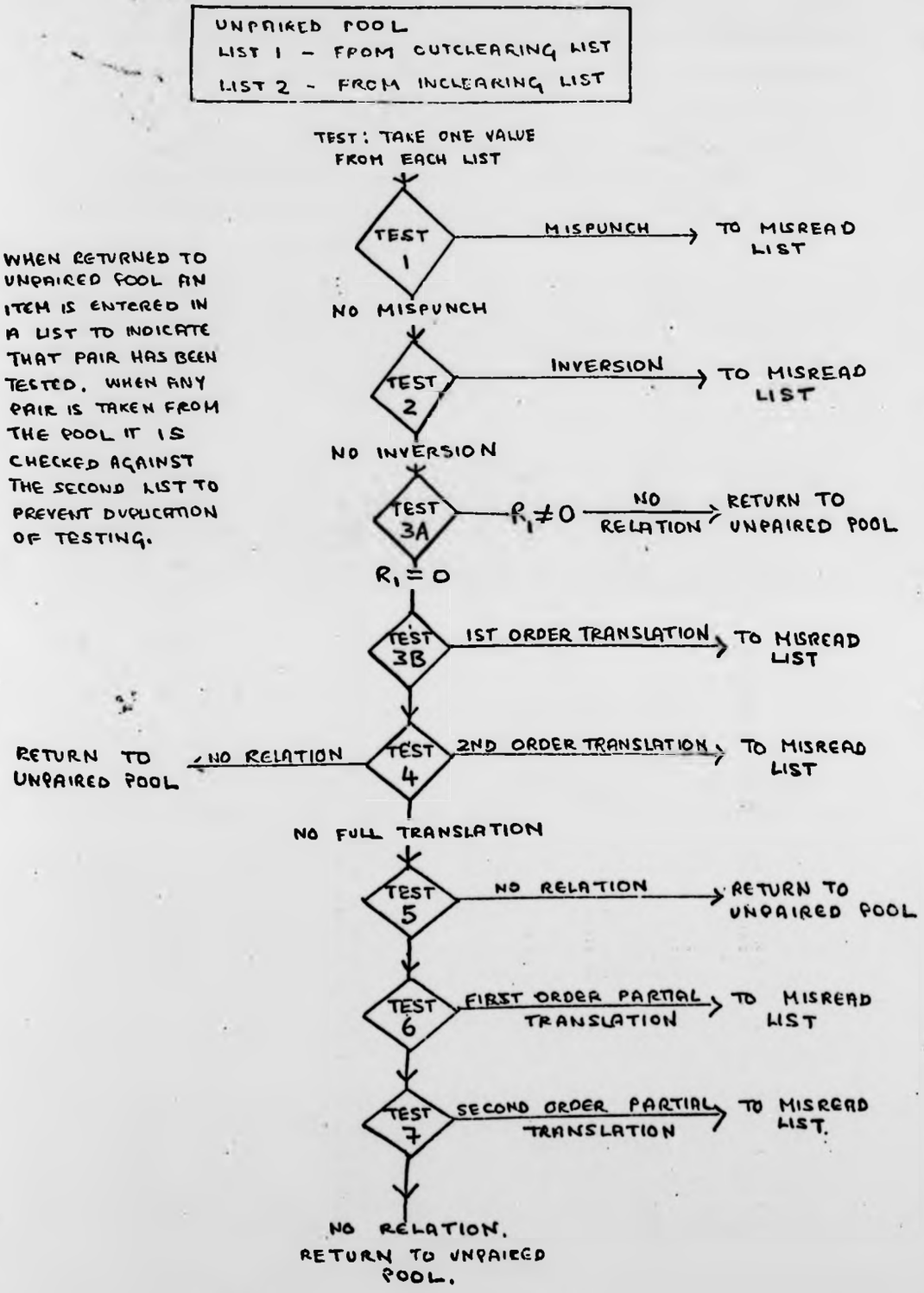

FIG 8.2. DIAGRAM OF FLOW OF TESTS FOR PAGE 196.

8.3.3 Other problems

Not all errors are contained in the difference schedules. For example, a wrongly amount-encoded cheque can be read by both banks as being for the wrong amount. This can be discovered by the branch (or if not, by the customer). Such errors are corrected directly with the crossing branch, but require accounting entries. They are not contained in the work of Reconciliation Departments.

8.3.4 Error Corrections

Some differences - those classified as "Other" i.e. such as INVALID BANK, INVALID BRANCH, INVALID ACCOUNT - can readily be corrected because the voucher in question comes to the Reconciliation Department for action. These involve such procedures as

a) returning wrongly-routed vouchers to the outclearing bank.
b) identifying the branch which holds an account, using the account number and name. (It must be borne in mind that account numbers are not unique in any Bank. The branch sort code is an integral part of the account identifier).
c) identifying the account on which a cheque is drawn. (This can be by circulating all branches with a photocopy of the signature to find a branch which recognises it as one of its account holders).

These procedures are not always successful, and are at best tedious. However, one advantage that they hold over others is that for cheques they in no way adversely affect the account holders of the inclearing bank, although they do affect, on some occasions, the account holders of the outclearing bank by preventing credits being completed. In the case of a credit which cannot be allocated, the situation is quite different. In that case the person paying the credit must be contacted so as to ascertain the correct destination for the money.

Manually sorted items are another source of problems in reconciliation because, until informed by a branch, there is no central record of the details of the vouchers. Branches also find in machine sorted bundles items belonging to them that are not listed, and items belonging to other branches. These are items which have pick-a-backed through the reader-sorter at various stages. Own-branch items have pick-a-backed early in the sorting and later been fine-sorted correctly. Pick-a-backed items become MISSING vouchers. In the case of manually-sorted bundles the branch cannot know which are MISSING, thus confusing the process of Reconciliation.

OVER items are fully known, but need to be identified with the relevant amount in some outclearing list. Thus these too must be traced to find the crossing bank. This narrows the possibilities when trying to identify an OVER item with a MISSING item in another batch, but cannot cater for those cases where a voucher has entered the system without being listed. This requires the co-operation of the outclearing bank, which should have a corresponding MISSING item somewhere in its records. As stated earlier, the crossing stamp may be illegible.

In the case of items with disagreement in amount the full code-line is known, and the branch can be requested to give the correct version, and a copy of the cheque or credit in proof. Considerable search time is involved in locating copies of vouchers.

8.4 A Computer System for Difference Reconciliation

In section 8.3, it was shown that it is possible to prepare on the computer difference lists with more information content than the lists currently manually produced for the Reconciliation staff. This computer list can tag to any difference the number of the batch that the difference-causing item was seen to come from, and this itself can be identified with the bank of origin. Thus, a total accurate picture of the available data can be computer-produced. Outprinted on a standard format this could be the basis for manual reconciliation. It could equally be the working base for a computer-based reconciliation. Such a system is outlined in this section.

The system proposed here is very much a poor alternative to establishing a complete information system with efficient data retrieval.

It is envisaged that with tape exchange and keying back-up as outlined earlier, the computer would produce a file of differences. In addition, the accounts necessary to trace the financial effect of difference corrections could be set up.

The basic difference file for each clearing date, and for each of credit and debit, would contain records of the following form:

Clearing Data	6 Digits
Credit or Debit	1
Item number	3
Source Bank	2
Source batch	4
Advised total of batch	10
Captured total of batch	10
Type of difference	4
Code line of voucher (if known)	24
Advised amount of voucher	10
Captured amount of voucher	10
Difference CR or DR.	11
	95 Digits
	= 48 Bytes

This file is used to produce daily listings for a number of users:-

USER

RECONCILIATION ACCOUNT	:	file totals.
OUTCLEARING BANK	:	using sort key of source bank and batch, a list of all differences with all data
INCLEARING BRANCHES	:	using sort key of branch code from code-line of voucher, a list of all vouchers with differences
RECONCILIATION DEPARTMENT	:	In addition to inclearing branch lists, a list of all differences, using sort key of source bank plus batch, and a list using sort key of difference type.

As errors are found, a new file is created which, in addition to the data on the original record, contains:-

Correcting Date	6 Digits
Identification for contra items with corrected accounts (date, CR or DR + Account identification and item numbers)	16
Correct amount of voucher	10
Real difference, CR or DR	11
Identity of correcting person	4
	47 Digits or 24 Bytes.

Thus, for each difference, a final file record would be under 100 Bytes.

Lists can be produced by the data processing system while the off-line sortings of vouchers are taking place, and can therefore be ready for despatch to branches with the vouchers of that day's clearing. On receipt by branches, relevant vouchers can be retrieved and photocopies made, so that full agreement on the correct version can be reached by banks.

The branch still requires to sort through its received bundle of cheques to locate any unlisted or mis-sorted items. Unlisted items should also be photocopied, while mis-sorted items should as at present be sent to the correct branch for action.

At the beginning of each day, on the computer one file exists for each day preceding for which there are records with non-zero difference. During each day, a set of corrections is keyed into the computer, and the system sorts these, using the key "clearing date of error/item number/CR or DR." The set of files is then updated, and all records in which differences are now zero are removed, thus creating the start-point for the next day's work.

This exactly mirrors the simplest operations in customer accounting, and can thus be done with a similar system. Correction accounts and lists can be produced in a manner analogous to the creation of general ledger accounts.

The basic set of files would occupy very little storage space. Current experience suggests some 300 items per day, which, after some ten working days are reduced to perhaps 20 items. After one month, about 5 items are left on record.

Thus, the storage space required for one year's differences would be less than:

300 x 10 x 100 Bytes		3000 x 100 Bytes
+ 20 x 20 x 100	=	+ 400 x 100
+ 5 x 230 x 100		+ 1150 x 100

i.e. less than 460,000 Bytes.

This is very small compared with the storage currently used for accounting systems.

The cost of this system must be compared with possible staff savings.

Currently some 20 - 30 Head Office staff work full-time on difference reconciliation. (This is in addition to the staff involved in difference identification). In addition we can assume on the basis of qualitative statements from Bankers that of the 20% of branch staff time presumed to be spent on clearing, some 25% is spent on difference reconciliation. Speedy identification of problem vouchers could reduce this 5% of branch staff time to 4%, thus saving some 70 from 7,000 staff.

The operation of the system would require keying, and on the assumption of 300 differences per day, some 5 full-time key to disc operators would be employed.

Thus, a system of this kind could mean a saving of some 90 staff, while at the same time bringing the clearings once more under effective control.

The costs would be the setting up of magnetic data exchange between banks for clearings, and the development and testing cost of the system, plus the annual cost of data exchange. These costs would quickly be recovered by salary savings.

The system would require built-in security measures, but no more so than ordinary bank accounting systems. (see Appendix H)

Thus it is possible to improve on the current Clearings, and minimize the results of having an incomplete base of data within the computer system. However, the nature of voucher clearings make it impossible to eliminate unaccountable differences.

8.5 Comment

This chapter, and the previous discussions, have demonstrated that the present mode of computerisation in the Scottish Banks has serious deficiencies in comparison with an ideal information system, as set out in Chapter 3. Problems so far considered are

- major information system users are not provided with the information they require. (Chapter 5)
- production runs are limited by physical sorting of paper, and not by computer capacity. (Chapter 7)
- voucher rejection by reader-sorters is significant.
- differences resulting from clearings are expensive to rectify.
- present systems do not have a complete base of data to use in difference correction or in information reconstruction.

Available technology for information systems has been discussed in Chapter 4. Its possible use in the Scottish Banks will now be considered against the background of the problems encountered in these Banks, to establish whether any improvement can be made to information production.

Chapter 9 : A Computer-Based Information System

9.1 The Philosophy behind the current system

In the current system data processing is used for essentially numerical accounting, while data transfer is achieved by the Clearings. The basic concern is to pass vouchers to the branch at which the relevant account is held. This is done traditionally because the account holding branch cannot operate on an account without adequate evidence of authority to do so. However, from the viewpoint of information systems, the main purpose of clearing is in fact to pass data through the banks, as this data is necessary at several points:-

1. At the outclearing branch for updating its general ledgers of credits and debits remitted.
2. At the outclearing Head Office to update collection accounts and payment accounts with other banks.
3. At the inclearing Head Office to update collection and payment accounts, and also for updating customer accounts.
4. At the inclearing branch to provide data on customer behaviour for management information.
5. At customer level, to provide total information on the operation of an account.

Thus these five users each require some of the data on cheques, plus the date of receipt; these requirements being,

At (1) the amount

At (2) the amount and bank sort code

At (3) the amount, branch sort code, customer account number, cheque serial number or credit deferment

At (4) the date of payment, payee name, signature, whether crossed, where paid etc. plus accounting data as in (3)

At (5) the date of payment, payee name or payer name (in the case of credits) plus accounting data as in (3)

Of these requirements (1), (2) and (3) are satisfied by the MICR code line in cheques, and can similarly readily be satisfied for credits. The data requirements at (4) and (5) are not satisfied by the code line. Further, the code line alone is inadequate for identifying technical errors. Thus, with current systems it is necessary for the voucher to be cleared as well as the data. Thus current computer systems cannot be called computer-based information systems because not all data required in the final information is present in the system.

This is in contrast with the direct debit, BACS giro credit and computerised standing order systems. For these systems full data on names of accounts, payee and payer is available on magnetic media. Signatures are required only once and thereafter not checked. Statements can thus be printed with the full information requirements of (4) and (5), and technical and other error tracing is built into the systems.

The Clearings do not use the full data processing capacity of computers, as set out in Chapter 4, as data is neither stored in nor transmitted via the computer. In addition, what data is stored is not easily retrieved as the relations between transaction items are not unique. Finally, by passing the cheques out to customers with statements, the Banks actually give away the only copy of data which is necessary for information reconstruction in the systems. They do not maintain a complete base of data on which to operate. Thus, the system fails against the basic criteria of a complete, readily available, information system.

The question naturally arises, therefore, whether it is possible to rectify these deficiencies within current technology, and at reasonable cost.

That there is a solution within computerisation has been realised by many Bankers, as witnessed by the discussion about cheque truncation.

No answer that satisfies all parties has yet been found because at no time has the question been clearly stated. The concern has been to move paper, rather than to create information systems.

In this thesis, the latter point of view has been taken. The users, their information requirements, and essential data items have been discussed in the preceding chapters. It has been commented that with volumes of work only a computer system can be readily available. This chapter suggests one method of establishing a complete computer-based information system, using modern technology.

9.2 Information System Proposal

The examination of the two main components of the current information systems of the Banks have produced the conclusions that:

a) No Bank produces only information, but also outputs data, in the form of vouchers.

b) No Bank has a complete base of data for its systems.

c) The data links in the information system are, except in the case of one Bank, very inefficient (see Glossary), and in all cases, data retrieval is costly. (See 5.1.2 and 8.1)

This section sets out proposals for overcoming these deficiencies, as a result producing not only a suitable Retail Bank information system, but also producing a structure onto which can be added improvements in services for all users.

The system proposed is a computer-based information system. The basic inputs to this system are

a) customer static and static alterations

b) the data on all vouchers

c) bank constants (interest rates, charge rates etc.)

The system is intended to remove virtually all the voucher clearings from inter-bank activity, with this replaced by data exchange. Automation will be limited to input, and will not be used for voucher sorting.

The system consists of subsystems:-

1) Data input

2) Voucher filing

3) Outclearing data processing

4) Banks interface system

5) Inclearing data processing

6) Information output

In order for this, or a similar system, to work, there must be full inter-bank agreement. The system could be phased in as banks joined the exchange agreement, by utilising current equipment for separating vouchers into agreed - and non-agreed - Bank bundles.

It is assumed that the cheque will remain in use, as there are a large number of cases in which it is the most suitable vehicle for payment yet invented.

This is, in fact, a major assumption, contrary to the public opinion expressed by many Bankers. At the present time, and for most of the decade under consideration, the Banking System has declared itself to be attempting to replace the cheque with various forms of electronic funds transfer. So far, in spite of the introduction of such alternative money transfer modes, the volume of cheques has continued to increase annually. At best, further growth is being diverted to non-cheque forms.

The author believes that this growth will, in the short term, continue, and that in the long term the cheque will continue to be used. Some aspects of the attractiveness of the cheque to users are set out in Appendix E, but by far the main advantages over all other forms of money transfer are that anyone, with or without a bank account will accept a cheque and will accept it for any amount. It does not rely on machinery, and does not even require the pre-printed forms. Only cash has its versatility, but cash is vulnerable to theft or destruction. Thus the author believes that the market will dictate that cheques remain a very prominent form of money transmission.

9.2.1 Data Input

Static data and Bank constants can be input as at present. The data on vouchers requires different treatment from the current system. At present, only basic accounting data - as on the MICR code-line - is input to the system. However, there is a considerable quantity of additional data that is required for a complete base of data to exist within the information system, and thus for complete information to be accessible. The data contained on a cheque is as follows:-

	1	Name of Bank
	2	Name of Bank Branch
	3	Address of Bank Branch
*	4	Sort-code number
	5	Account name
*	6	Account number
*	7	Signature
*	8	Serial number

* 9 Payee name

* 10 Amount in words

* 11 Amount in figures

* 12 Date of writing

* 13 Whether crossed and crossing details

* 14 Whether cheque card and cheque card number

* 15 Endorsements

16 Crossing Bank Branch Name

17 Crossing Bank Branch Address

* 18 Crossing Bank Branch sort-code

* 19 Crossing date

Of these, item 4 duplicates data in 1, 2 and 3.
item 6 duplicates data in item 5.
item 18 duplicates data in 16 and 17.

Thus, those items asterisked are the essential data items. Item 10 is best checked by the crossing bank which should then be liable for losses incurred by those items in which amounts in words and figures differ. Amounts in words are not suitable input for computer systems, and should therefore be subject to clerical scrutiny for acceptability.

The cheque need contain only the items asterisked, but there are disadvantages in this:

a) the form is not easily human-identifiable as being related to the non-asterisked items - e.g. the payer could easily confuse forms from different accounts

b) a computer-input form is unattractive to people.

c) there could be customer suspicion if no bank name was visible - the payee might not accept the cheque.

d) it would be easier to make forgeries.

Thus, it is not proposed that the redundant items be omitted from the cheque, but only that they be omitted from the keying.

The standard ordinary cheque size is 6.5" x 3", although companies can choose to use a large cheque format. All the data listed is currently contained on such a size of cheque, although certain items are normally written on the back, e.g. the cheque-card number, and endorsing signatures. Stores tend to put additional data on the back, such as the customer address, and the address of the department taking the cheque.

These items are not relevant within the information system proposed, and can therefore continue to be endorsed on the back. The cheque-card number, and direct endorsements (such as "pay to the account of Joe Bloggs") are relevant data, and should go on the front.

The small format allows little room for all necessary fields, and it is therefore proposed that the bank name forms a significant part of the cheque background, rather than using up space that can otherwise be used for codes. However, to allow for human-readability, this background printing should be in a light colour.

To accommodate banks not adopting the system the current MICR line can remain, with space allowance for amount encoding.

A cheque should therefore be re-designed to take account of these data items. However, the cheque is also a document to be used by people, and these two aspects must be accommodated. There are, therefore, human and machine constraints:-

Human constraints:

The cheque must be

Ia) a comfortable size

Ib) easily understood

Ic) made of suitable paper

Id) set out with space for handwriting.

Machine constraints:-

IIa) there must be a standard format

IIb) for speed of keying it should be one-sided

IIc) it should be within a range of standard sizes

IId) there should be paper and encoding standards where possible - i.e. pre-printed data should be machine-readable.

IIe) there should be spaces for input codes to be added before keying

Item IId does not imply the use of MICR, because other machine readable coders - for example OCR - have been adequately developed since MICR was first adopted by the Banks. However, there is a strong likelihood of economic inertia due to the sunk costs in MICR technology, making this type of coding attractive for pre-printed data.

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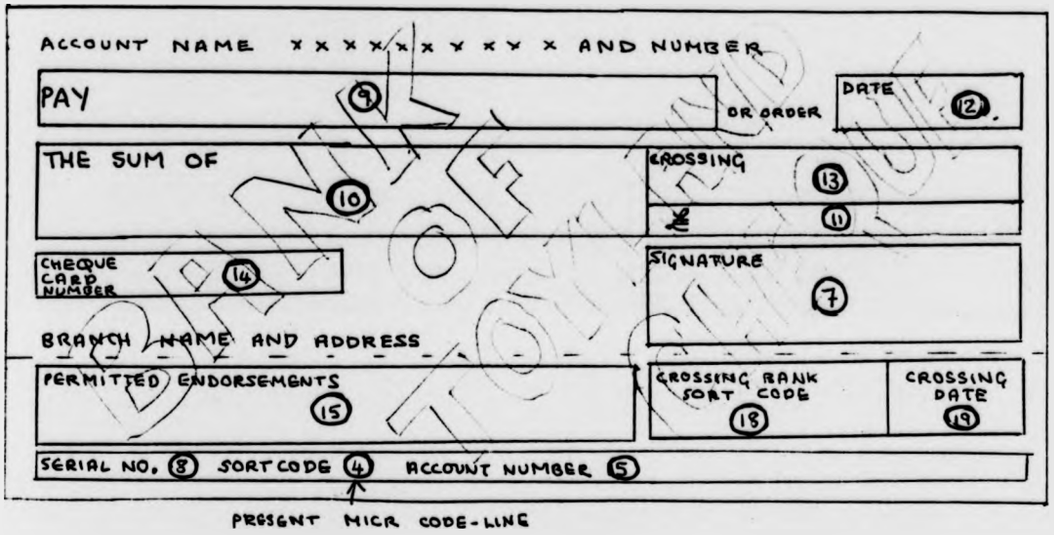
FIG 9.1

A proposal for a cheque as an input document.



NOTES 1 The larger size cheque contains adequate space for two signatures.

2 It will be noted that this cheque design allows for the 13 essential fields listed in this chapter. Of the redundant fields, only the crossing Bank Branch name and address are missing. As it is the intention that the voucher be filed with this bank this data is totally unnecessary when sort code and crossing date are available.

The system here does not propose MICR encoding of amounts onto cheques.

Credit vouchers can similarly be redesigned on standard format, to contain all necessary fields, as listed:-

GIRO CREDIT

Sort-code number, name of bank, address of branch.

Account number

Amount in figures

Name of recipient

Name of payer

Crossing bank sort-code

Crossing date

Credits do not have the "amount in words" and signature requirements of cheques, because they have no legal standing. It is normal for Banks to issue receipts for these items, and this should be continued, but with the receipt containing a transaction identification number.

No relevant endorsements are currently placed on the back of giro credit forms. The values of the components of a total credit are identified by the transaction number.

Actual input of data to the computer occurs in two stages

1) the input of basic accounting data, at which time a transaction number and item number for the voucher within the transaction are allocated
2) the duplicate keying of basic accounting data (to minimize the chances of errors in keying) and the keying of the remaining data fields.

It is envisaged that the basic accounting data is input via a teller-terminal, by the teller and a machine code-reader.

The teller would inform the computer that a transaction was taking place. The computer would allocate and print out a transaction number, consisting of date, and a four-digit serial number.

Items within the transaction are then allocated sequential two-digit numbers as their amounts and encoded identification are fed into the system. (In the case of credits the teller must key in the destination account details. For cheques, the machine can read the code-line).

The transaction number has added to it, by the computer, the six-digit sort-code number of the transacting branch. It would be an advantage at the next keying stage if print-out were on a paper size and standard compatible with cheques and giro credits.

It should be noted that teller terminals used currently in the Scottish Banks do not have the capacity to read MICR or OCR, although they can read magnetic stripe cards. However, desk-top MICR and OCR readers exist, and so a suitable teller-terminal can be designed within current technology.

The vouchers in any transaction would then be bundled together with a transaction summary printed by the terminal. This summary contains the transaction number. The vouchers are then sent for full keying at a fast-keying centre with a keying staff of (perhaps) 10, or 20.

At this keying centre, most of the fields are keyed, or, if encoded, uplifted by the machine. This requires a document handler, first with an MICR/OCR read-head, then a keying position, and finally an image lift unit. The document handler would pass the vouchers through the read-head. A teller-terminal print-out would identify the existence of a new transaction. With printing in OCR readable font, the machine could identify which transaction and the crossing bank branch and crossing date. Otherwise, this must be keyed by the operator. Each voucher is then presented to the operator in turn, with all encoding read. For cheques, the operator keys in fields 9, 11, 12, 13, 14 and 15. The operator also keys those that the computer identified (via a display) as unreadable. Credit encoding is similar.

After keying, the voucher then passes an image-lift device which

a) images the complete voucher for filing

b) selects the image of the signature or signatures of cheques and adds this field to the computer record for the voucher.

The voucher is then passed, without sorting, to a pocket of keyed vouchers. These can then be stored until the computer notifies the branch that full records are established.

9.2.2 Voucher filing

The filing of vouchers can be done either in their physical form, or in the magnetic image form created at the last stage of keying. In either case, appropriate indexing and file back-up must be provided. It is the intention in this system that only exceptionally will vouchers be accessed after the second keying - the incidence equivalent to the current experience of returned vouchers in those technical situations that the crossing bank cannot cater for - i.e.

1) inadequate funds, non-guaranteed
2) closure of account
3) death of account holder
4) liquidation
5) appointment of receiver
6) forgery, or non-existent account etc.
7) stolen cheques and card.

This incidence is low.

It is also the intention that duplicate keying should draw attention to such situations as

8) missing fields
9) conflicting fields e.g. out of date cheque

which would reduce the requirement for clerical labour at inclearing banks. Discovery of such conditions would draw attention to the need for immediate correcting action, rather than deferred action as at present.

9.2.3 The Signature

There is a strong argument for saying that no image of the signature is required on the computer file, and that, as a result, the replacement of the proposed image-lift unit by a microfilm unit would be acceptable, and in addition, that the record size could be considerably reduced by the elimination of the requirement to store and process the signature image. The pros and cons are set out here.

A cheque which is technically correct, contains on it a date of payment, and a signing name. Unless the account holder has informed his bank that his cheque book is stolen, the use of the correct name implies virtual certainty of correct usage. If, in addition, the cheque has on it a cheque card number, this further implies that the signature has been duly checked by the receiving party.

However, these inferences are not necessarily valid. Firstly, an account holder may not know that a cheque (or cheques) has been stolen. Secondly, cheques sent through the post do not contain a cheque card number (and should not, as the payee has not seen the card). Thirdly, even if the payee does view the card, his interest is in the guarantee that it gives him, and not in the correctness of the signature. Thus, without access to an image of the cheque signature the paying bank cannot promise customers the level of security currently possible with the return of cheques to the account holder. Arguably, in cases of dispute, the bank can approach the crossing branch for access to the original voucher (or microfilm copy). However, that particular safeguard is considerably weaker than having the signature image on the bank's own files. Thus, it is suggested that signature imaging should form an integral part of the data input to the system.

9.2.4 Outclearing Data Processing

The crossing bank's computer now has two files

a) a file of transactions and basic accounting data

b) a file of transactions and full accounting data

(In addition there is a third file for storage containing transaction identification number, and images of vouchers with their item number within the transaction. This is not used in the data processing).

The computer processing system then does two things:-

1) it checks that the two files match

2) it creates files for other banks, containing accounting data.

Since file (a) is prepared only during bank opening hours, it is proposed that a copy of this file is used for primary clearing.

This primary clearing or financial clearing, is virtually identical to the data processing component of the current clearings and similar to current proposals for cheque truncation. The basic accounting information has added to it the bank transaction number and item number, with transactions then split into the component credits and debits. The components are then sorted to the various other banks, and tapes prepared which contain records of the following form:

TRANSACTION NUMBER	Crossing Bank Sort-Code	6 DIGITS
	Date	6
	Transaction Serial Number	4
	Item number	2
ACCOUNTING MOVEMENT	Paying Bank Sort-Code	6
	Serial Number of Voucher or CR Identifier	6
	Account Number	8
	Amount	10
		48 DIGITS

As in the current clearings, Banks would settle the requested amount on the clearing day, and adjustments would be made later. The inclearing bank then applies the accounting data to its own accounting system and deducts or credits as appropriate; again with corrections later.

File (b) is prepared as vouchers reach keying centres. This file (in duplicate for security) contains records, which for cheques are as follows:-

*	TRANSACTION NUMBER		18 DIGITS
*	ACCOUNT MOVEMENT		30 DIGITS
*	PAYEE NAME	LIMITED TO	18 CHARACTERS
*	DATE OF CHEQUE		6 DIGITS
	ENDORSEMENTS	LIMITED TO	30 CHARACTERS
	CROSSINGS	LIMITED TO	18 CHARACTERS
	CHEQUE CARD NUMBER		8 DIGITS
*	IMAGE OF SIGNATURE(S)	500 BYTES PER SIGNATURE	(1) 500 BYTES (2) 1000 BYTES

Items which must always be present are asterisked.

From this file alone the computer can carry out some checks for technical correctness

1) cheque not out-of-date
2) cheque signed
3) existence of payee, of amount in words (from image)
4) existence of account number, sort-code number.

Absence of essential fields can be notified to the branch, and the voucher retrieved for action.

In addition, the presence of an additional code sign in the pre-encoded section could identify the requirement for more than one signature, or even of two signatures required above a certain value. Absence of a second signature would therefore cause the computer to refuse the record as incomplete.

This file is then compared with the basic transaction file, and a new file created of transactions in which the two keyings are different. The branch is notified of the discrepancy, and vouchers are retrieved to establish the correct position.

After this checking the file is sorted into outclearing format, and the secondary clearings, or data clearings take place. This is not a complete sort, requiring only that data relating to the same bank be bundled together. Thus, some dozen or so files can be set up at each outclearing, to which relevant records are randomly posted. Thus, the record size does not present technical sorting difficulties.

It is not essential that the clearings should be split in this way. The reason for this split is precisely the variable nature of the number of transactions received at branches throughout the week and month. The secondary or data clearings are in fact the major clearings, and include all that is contained in the primary clearings. The split need only occur on peak days when voucher keying falls too far behind to enable the fully checked version to be used in the day's settlement. The primary or accounting-only clearings consist of records which are about 25 BYTES in size, and can therefore be sorted quickly by outclearing banks if so required.

9.2.5 Banks Interface System

Full standards would have to be agreed on data exchange. It is envisaged that data communication links would be used with full tape back-up, in a system similar to the system currently used between the Banks and B.A.C.S.

9.2.6 Inclearing data processing

Data received is verified against technical criteria, and then checked against in-bank records for technical acceptability. Card numbers and dates of writing are compared against lists of lost or stolen cards. Serial and account numbers are compared against lists of stopped cheques, and accounts in which movements are not allowed. A file of such rejected items is prepared, and transmitted to the outclearing bank. The accepted records then form part of the base of data for the accounting system of the bank. Some data from the records is used to complete branch and head-office information, and also to prepare customer statements. The full record consists of 45 to 97 BYTES, plus 500 Bytes for each signature.

Not all of the basic data need be used in the customer statements, only the 45 Byte part of the record being required for all cheques. With the present sort key of branch code and account number, there is no technical problem in sorting, this basic record size being not very much larger than in the present system. Not all data is sorted - the signatures are kept in order of receipt, but indexed and available when required. After immediate use for accounting and customer statement preparation full records can be output to archival storage, after a short time lapse.

9.2.7 Information Output

The processing system produces lists of unacceptable items which are returned to the crossing bank. This also creates adjustment schedules for clearing payments for the Chief Accountant's office.

The records, sorted into branch order, and applied to accounts are used to create further schedules.

1) a schedule of irregular items - e.g. where application of a debit makes an account go below the authorised limit.
2) a schedule of the day's records, allowing for technical checking.
3) an index of signatures against the cheque serial number (which could permit some video representation of the signatures) to allow for checking facilities.
4) fully documented customer statements for the manager, detailing items as on customer statements, plus
   - date of cheque
   - cheque card number if used
   - crossing bank
   - crossing date
   - whether crossed, and crossing if used.
5) customer statements, which contain, in addition to the data currently printed on statements, the name of the person to whom the cheque was paid, or source of a giro credit, and the date of cheque writing or credit issue.

9.2.8 System Costs

No bank has yet installed a full Image Processing system. The installation and operating costs are therefore unknown. Image Processing is currently being developed by computer manufacturers. It is at an advanced stage, but without sufficient market interest, no company is prepared to quote. The machinery itself is, however, not elaborate, in comparison with current reader-sorters, the Burroughs experiment, for example, merely adding an optical unit to an otherwise standard piece of machinery. It is the software which is expensive. Were computer companies to see sufficient sales of the software, they would be prepared to quote competitive costs.

Without these costs, no hard economic comparisons can be made between current systems and the above system proposal, except to say that, apart from the Image Processing, the system design cost would be similar to that of rewriting a full accounting system - a task which is, as stated in earlier chapters, already overdue. However the staff requirements of the two systems can be compared.

It has already been noted that the records required in this system are large, although they are not so large as to prevent same-day processing and it must be asked how many staff would be required as keying operators.

As already indicated, credits require virtually no keying beyond what is already done, so that the essential comparison is in cheque keying against paper clearings.

At 1980, about 60 million cheques were cleared by each of the Banks in Scotland. This implies an average of 240,000 cheques each per day. Calculations will therefore be done to estimate how many staff would be required to process 300,000 vouchers per day.

There would be no additional teller work. The first additional work occurs at the duplicate keying. If the teller terminal outprints transaction forms with OCR readable transaction numbers, then each cheque will require between 30 and 86 key depressions, with the average being about 40 key depressions. This can be further reduced by not keying duplicated fields on related vouchers.

With purely numeric data operators can process at a rate of 10,000 key depressions per hour. The requirement for alphanumeric characters will reduce this to, say, 7,000 key depressions per hour. Thus 300,000 vouchers require 12 million key depressions, which would take 1,715 operator hours, requiring 245 operators, working a 7-hour day.

This has to be compared with the staffing requirement for paper clearings, which consists of some 150 - 200 staff at Head Offices, including encoders, sorters and machine operators, and considerable reduction in branch work-load by the removal of the calling-off of cheques against lists, the filing of cheques into customer statements, and the packing of cheques in envelopes for customers. This uses at least 500 staff per day.

The system would require some filing staff - up to 100.

Thus, a system processing 12.5% greater volume would use less staff than current requirements, saving the cost of about 300 staff per annum.

This calculation is summarised in TABLE 9.1.

TABLE 9.1 Staff Implications of present vs proposed system.

Present system : average of 240,000 cheques per day.

150 - 200 clearing staff at Head Office

500 branch staff (approximately)

Total of approximately 650 - 700 staff involved in clearings.

Proposed system : average of 300,000 cheques per day.

average of 40 key depressions per cheque.

average of 7,000 key depressions per hour, per operator.

Average number of required operator hours $= \frac{300{,}000 \times 40}{7{,}000} = 1{,}715$

Average number of required operators, with 7 hour day $= \frac{1{,}715}{7} = 245$ operators

Number of filing staff required approximately 100

Total, approximately 345

Possible staff saving approximately 650 - 345 = 300.

There is therefore a potential significant saving in staff using Image Processing, and this saving could be used to offset some of the costs of software.

The main problems in implementing this system are firstly, in overcoming system design difficulties, and secondly in obtaining the agreement of Bankers to change current systems, and alter the legal framework surrounding the cheque.

The first of these problems involves the unknowns of research and development, but would be overcome if the market demanded it. The major obstacles to changes such as the proposals in this chapter are within the Banks themselves: it is notoriously extremely difficult for Bankers to reach agreement on standards.

However, the main system advantages appear in the forms of accuracy, reliability, correctibility, accessability, and complete information content. In addition, being a full computer-based system it can be designed to be adaptable to new developments in customer and other user requirements. It looks to the future, rather than being tied to the past.

From the point of view of the advantages and capabilities of computers, the current systems are therefore not the closest possible approach to the ideal information system set out in Section 3.1, and thus it can be concluded that the current mode of computerisation, given modern technology, is no longer optimal.

Chapter 10 : Conclusion

10.1 Resume

In Chapter 1 the aims of this thesis were stated as follows:-

1. To identify the operational needs of the Scottish Clearing Banks, and, by determining the capabilities of equipment, to assess what contribution computerisation can make towards satisfying these needs.
2. To examine the mode of their computerisation in the past, and assess the impact of the decision to computerise, both directly in economic terms, and indirectly in expanded services and structural change.
3. To examine the continued suitability of their present mode of computerisation.

These aims were further broken down and inter-related in Section 1.3 "Plan of the Thesis."

In considering the operational needs of the Scottish Clearing Banks, in the light of their history as retail banks serving Scotland, offering accounting and money transmission services, it is concluded that, underlying their immediate objectives of providing for money transfer and carrying out accurate and speedy accounting, is the fundamental operational need of information systems to serve a number of users, ranging from the customer to senior management.

Consideration of how the three Banks have changed during the decade (Chapter 2) demonstrates that information requirements have increased in recent years because of a number of factors, including expanded involvement in non-retail activities, and also government regulations on Banking. However, the fundamental information needs of customer accounting and money transmission continue to dominate.

The Banks are profit-making organisations, and a consideration of the source of their profits and causes of their costs (in Chapter 3) demonstrates that the inability of an individual bank to influence interest rates and other market or government controlled factors, makes it imperative that the cost of information be contained to ensure profitability. In addition, information must be readily available, and speedily produced. In Chapter 4, consideration of modern equipment demonstrates that computers are capable of converting the available data into the required information within bank constraints. In addition the volumes of work are such as to make computerisation cost effective.

. However, the requirements of all Banks are inter-related, and the information systems must as a result be compatible at interfaces. Further consideration of the suitability of computers to provide this in addition to internal information systems for individual Banks forms part of Aim 3 and was deferred to later chapters.

For Aim 2, the mode of computerisation was examined both in terms of the overall hardware and expansion of Systems Divisions (Chapter 2), and in terms of the systems themselves (Chapters 4 and 5). It was seen that computerisation began in the 1960's. Each Bank developed its systems independently, although common agreement was reached on the mode of computerisation. This was virtually dictated by the limitations of technology at the time, and involved the automation of cheque sorting, using MICR encoding. Data processing equipment was then very restricted, both in speed of operation and in central processor memory, and as a result it was not possible to process all the data on cheques within computers. The time-honoured Clearing process, whereby data on cheques reached accounts by the cheque actually being sent to the branch, continued to be attractive. Therefore a system was developed in which these data carriers were automatically passed through the system. Only the numerical accounting was carried out on the computer, and as a result the two main users of the information systems - the customer and his branch - were still supplied with an account summary, and a package of data on vouchers (see 5.4). This system continues today, although all Banks have modern sophisticated equipment capable of a more advanced information system. (see 4.3). This is the case because Bankers regard the Clearings as the exchange of orders to pay, rather than as an exchange of data carriers, and in addition no suitable alternative has been agreed on.

From the customer viewpoint, computerisation has only recently had any impact on banking. However, from the point of view of the Banks, there was a major change in the position at which accounting was carried out - having moved from the branch to the computer centre. All other functions remain at the branch. (See Chapter 5).

The transaction, which is the basic Journal entry in branch accounting, continues to be crucial. In the current system, however, individual credits and debits form the basic input, and there is not in any Bank an index kept which allows access to the full identification details of all the components of transactions. (See 5.1.2). The lack of such an index greatly increases the difficulty in reversing transaction components when a voucher fails to pass through the Clearings.

This particular aspect of the current mode of computerisation was considered again in Aim 3, where emphasis was placed on transaction numbers for use in data retrieval.

The mode of computerisation can be summarised as computer-assisted information production based on automation.

The second part of Aim 2 was concerned with the direct and indirect results of computerisation. The indirect results were considered first in Chapter 2. It was there concluded that computerisation has been one cause of the expansion of bank services, and considerable structural changes have taken place in the Banks following computerisation. In particular, Computer Divisions have emerged, reflecting the importance of the equipment in the provision of services. Sophisticated information systems in which cheques are not used have been developed in all the Banks. These systems, including electronic funds transfer systems, have a very high reliability, and give user satisfaction. They demonstrate that it is the information on cheques, and not the cheques themselves, that is essential to users.

This observation (in Section 5.4) raises the highly important question whether vouchers must be moved, and this question is crucial to Aim 3.

The final part of Aim 2 was to assess the impact of computerisation in direct economic terms. In Section 3.3 examination of the Banks' profits demonstrated that no immediate conclusion could be drawn about the effect of computerisation on profitability. Consideration of the growth of workload and staffing in the Banks (Sections 3.4, 3.5 and 6.1) led to assumptions which could be used in a model to assess the accumulated results of cost changes arising from computerisation.

First, in Section 6.2.1 the economics which led to the computerisation decision by Bank managements were reviewed. Underlying the decision to computerise was in the case of each Bank the desire to streamline clerical and production work, in an effort to contain costs. Over the decade 1970 - 1980 there was considerable growth in work volumes, but at the same time a great increase in the number of staff. It had been the hope that computerisation would contain staff growth, but work growth was considerably above expectations. The model in Chapter 6 demonstrates that, (in spite of the growth in staff numbers) under a variety of assumptions, given the numbers of staff in each of the three Banks at 1965, each Bank has saved considerably in costs over the period of computerisation. Since, in the theory of Chapter 3, reduced costs imply improved profits, it can be concluded that computerisation has, in all three Banks, enhanced profits.

The thesis changed direction in Chapter 7 to consider Aim 3 - whether the current mode of computerisation continued to be suitable for the future. Up to Chapter 7 the thesis is concerned with whether computerisation has been an improvement in cost terms on the manual systems. In the later chapters the thesis is concerned with whether the current mode of computerisation is the closest approach which can be made to an ideal information system, as set out in Section 3.1. In these later chapters, not only cost, but accuracy, and timely production of information are important considerations in assessing optimality of the current approach for the future.

Thus, the shortcomings of the current systems become the focus of attention. The questions of the interfacing of Bank systems, and whether vouchers must be moved are central.

One shortcoming of the current system is in the automation-based paper clearings. The operation of the Clearing system is seen to be unsatisfactory, particularly with the level of rejections from reader-sorters, and with the requirement for meeting Clearing deadlines. Cost-effective reject-re-entry systems can be developed. However, within the current mode of computerisation, Clearing deadlines will continue to pressurize work. Further growth in work load will require expanded sorter capacity, which can only be provided using additional machines and larger premises. (Chapter 7).

. In addition, there is in the current system inadequate data validation at input, and the automatic sorting equipment is itself capable of introducing errors. No Bank retains copies of vouchers in easily retrievable form, and all three Banks pass vouchers to customers with statements. As a result, no Bank has a complete base of data from which to reconstruct system output, and this makes it impossible for all errors to be corrected, or all differences to be reconciled. (Chapter 8).

With the banking requirement for accuracy, the current clearing system therefore is out of control.

It is possible, within the current mode of computerisation, and with a saving in cost, to identify most vouchers involved in differences, before they leave the system, and thus to bring the Clearings virtually under control. This would first require all cheque codelines to be input to the computer - requiring therefore a full reject-re-entry system - and also magnetic data exchanges between banks in parallel with the handing-over of vouchers.

Improvements can be made to the current system, but none of them can change it into a complete computer-based information system, as set out in Section 3.1. Closer approach to this ideal is possible, in a cost-effective manner, using the capabilities of modern technology.

Before such an information system can be set up, attention must be given not to the cheque, as at present, but to the information content of the cheque, this arising from the question of whether vouchers must be moved. Considerable discussion between major system users will be needed to determine what data is essential to maintain information content. Provided agreement can be reached, and the system design difficulties overcome, a revised system, using automation only for data input, and not for data transfer, would be equally cost-effective, more reliable, and amenable to system extension. The system design difficulties are likely to be surmountable, and as a result the agreement of users is likely to be the greatest obstacle to such a system in the future. With this proviso, the current mode of computerisation is no longer optimal.

10.2 Recommendations

1 Banks should develop a complete computer-based information system with efficient data retrieval. As paper vouchers are vulnerable to loss or damage, the data contained on them should be extracted as early as possible in the system, and thereafter, the computer should control the flow and storage of data. Adequate input validation must be carried out. The system must be such as to permit full output reconstruction for validation and error correction.

The information should be in the form and at a cost suitable for system users. To set up such a system, Banks and users must agree on the information content of vouchers. A revision of voucher format would ease use as a computer input document. Banks should agree to interchange full magnetic files of relevant data to permit access to images of vouchers for signature checking and fraud detection. There should be agreement between Banks to accept responsibility for the technical adequacy, in so far as their knowledge allows, of input documents accepted by them.

2 In the absence of a full computer based system, improvements are required in the present system.

The Transaction

It is recommended that the transaction number be used as an index to the complete identification code of all vouchers in any transaction, and that files be set up which can be searched using the identification code, in order to identify the source transaction of a voucher and the identity of all associated vouchers.

Reject-re-entry

It is recommended that reject-re-entry systems be developed so that there would be in the computer files a record of all vouchers passing through clearings.

Clearing Differences

It is recommended that Banks agree to magnetic data exchange in parallel with Clearing of vouchers, so that the computer could identity the vouchers involved in Clearing Differences on a timely basis, so that these could speedily be retrieved.

Base of Data

It is recommended that an image (magnetic or otherwise) is made of all vouchers as they enter the system, so that data can be reconstructed in the case of voucher loss or damage. It is also recommended that all vouchers should be imaged on receipt by Clearing Departments, so that a complete base of data is available, to allow the reconciliation of Clearing differences.

10.3 Further Research

10.3.1 What is information?

This research has disclosed a lack of agreement in banking about the nature of information, the confusion being caused by the existence of the cheque, a voucher with legal significance. The question can be considered a philosophical one, but the answer, in the case of the Banks, has had a fundamental effect on the mode of operation, and hence of computerisation. The extent to which confusion about the nature of information causes the creation of sub-optimal systems in finance, and in commerce generally, could be examined.

10.3.2 What is a Branch?

It has been commented that the major effect of computerisation has been to remove the accounting from branches. This prompts questions about the nature and purpose of branches, and suggests that their original function, as an agency or sales centre, remains their dominant feature. Examination of the operation of branches in this light could form the basis of a reappraisal of branch computerisation.

10.3.3 The market for Bank services.

The question of the market served by the Banks, and the extent to which other institutions have invaded this market during the last decade has been mentioned in passing. Modern technology has changed the economics of many aspects of banking, and suggests that fuller research into market structure could prove valuable.

10.3.4 The value of computer equipment

Each of the Banks has invested different amounts at different times in computer equipment. Fine detail of such investment has not been available to the researcher. Should such details, and data on other expenses, be available, it might be possible to assess directly the impact of investment over specific periods on Bank profits. Such an analysis could then be extended to other commercial fields.

THE END

APPENDIX A

RETAIL PRICE INDEX JAN 1970 = 100

	70	71	72	73	74	75	76	77	78	79	80
JAN	100.0	108.5	117.4	126.5	141.6	169.8	209.5	244.2	268.4	293.5	347.3
FEB	100.6	109.2	118.0	127.3	144.1	172.7	212.2	246.6	270.0	295.9	352.4
MAR	101.1	110.1	118.4	126.0	145.3	176.1	213.3	249.0	271.7	298.3	357.2
APR	102.7	112.5	119.5	130.5	150.3	182.9	217.4	255.4	275.6	303.4	369.4
MAY	103.0	112.5	120.1	131.4	152.4	190.5	219.8	257.4	277.2	305.8	372.8
JUN	103.3	113.9	120.8	132.2	154.0	194.2	221.0	260.1	279.3	311.0	376.3
JUL	104.1	114.6	121.2	132.7	155.4	196.3	221.4	260.3	280.6	324.5	279.5
AUG	104.0	114.7	122.2	133.1	155.5	198.2	224.5	261.6	282.4	327.1	380.3
SEPT	104.5	114.9	122.9	134.3	157.2	199.0	227.5	263.0	283.6	330.3	382.7
OCT	105.7	115.4	124.6	137.0	160.3	201.8	231.6	264.2	284.8	333.7	385.1
NOV	106.4	116.1	125.1	138.0	163.2	204.2	234.8	265.4	286.8	336.7	388.2
DEC	107.1	116.7	125.6	139.0	165.6	206.8	238.0	266.9	289.2	339.1	340.3

	60	61	62	63	64	65	66	67	68	69
JANUARY	69.8	70.1	73.8	75.8	77.3	80.9	84.4	87.5	89.8	95.3
JULY						83.3	86.1	88.0	92.6	97.6

% INCREASE ON PREVIOUS YEAR AT JANUARY OF EACH YEAR

YR	%	YR	%	YR	%	YR	%	YR	%
61	0.4	66	4.3	71	8.5	76	23.4	81	12.2
62	5.3	67	3.7	72	8.2	77	16.6		
63	2.7	68	2.6	73	7.8	78	9.9		
64	2.0	69	6.1	74	11.9	79	9.4		
65	4.7	70	4.9	75	19.9	80	18.3		

APPENDIX B MAJOR SYSTEMS IMPLEMENTATIONS OF THE SCOTTISH BANKS

Dates of Implementation of Some Major Computer Systems in the Scottish Banks.

SYSTEM	RBS	B of S	C.B.
DEPOSIT ACCOUNTS	PRE 1970	1973	1973
BASIC CURRENT ACCOUNTS	PRE 1970	1970	PRE 1970
DEBIT CLEARINGS	PRE 1970	PRE 1970	1974
STANDING ORDERS	1973	1971	1975
BACS CLEARINGS	1972	1972	1972
DIRECT DEBITS	1976	1976	1976
CREDIT CLEARINGS	-	1978	1977
RANDOM REMITTANCE	1977	1974	1978
REJECT RE-ENTRY	-	-	1980
CHEQUE PERSONALISATION	1975	PRE 1970	1979
MICROFICHE CURRENT ACCOUNT LEDGERS	1978	1978	1978
BACK OFFICE TERMINALS	1970	1970	-
CASH ISSUING TERMINALS	1978	1979	1977
TELLER TERMINALS	1979	-	1978
CARD DEPOSIT ACCOUNTS	1980	-	-

APPENDIX C : CALCULATIONS OF CUMULATIVE BANK COSTS OVER 1965 TO 1980

Table C1

	Property and expenses per staff member @ 65 x property index	Average Salary/ Staff Member
65	1010	1010
66	1131	1020
67	1212	1070
68	1313	1120
69	1465	1180
70	1616	1250
71	1768	1370
72	2020	1470
73	2273	1560
74	2828	1890
75	4040	2400
76	4444	2800
77	4697	2990
78	4848	3300
79	5252	3650
80	5505	4360

Table C2

FACTORS AT 1980 PRICES

YR	Salary/Staff Member	Property & Expenses per Staff Member	Jul 80 RPI / Jul YR RPI
65	4602	4602	4.556
66	4494	4983	4.406
67	4616	5229	4.314
68	4588	5378	4.096
69	4589	5697	3.889
70	4556	5890	3.645
71	4536	5854	3.311
72	4600	6323	3.130
73	4460	6499	2.859
74	4615	6906	2.442
75	4639	7809	1.933
76	4799	7617	1.714
77	4359	6848	1.458
78	4461	6554	1.352
79	4266	6140	1.169
80	4360	5505	1

65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1000	1070	1145	1225	1311	1403	1501	1606	1718	1838	1967	2105	2252	2410	2579	2759
1060	1134	1214	1299	1389	1487	1591	1702	1821	1949	2085	2231	2387	2554	2733	
1113	1191	1274	1363	1459	1561	1670	1787	1912	2046	2189	2343	2507	2682		
1158	1239	1326	1419	1518	1624	1738	1859	1990	2129	2278	2437	2608			
1204	1288	1378	1475	1578	1689	1807	1933	2069	2214	2368	2534				
1252	1340	1433	1534	1641	1756	1879	2010	2151	2302	2463					
1302	1393	1490	1595	1707	1826	1954	2091	2237	2395						
1354	1449	1550	1659	1775	1899	2032	2174	2327							
1408	1507	1612	1725	1846	1975	2113	2261								
1465	1567	1677	1795	1920	2055	2199									
1523	1630	1744	1866	1997	2136										
1584	1695	1813	1941	2076											
1648	1763	1886	2019												
1713	1833	1961													
1782	1907														
1853															

Staff requirements with 7% work growth.

Annual Growth Rate

No Computerisation	7% p.a.
First Year	6% p.a.
Second Year	5% p.a.
Subsequent Years	4% p.a.

Table C3

MODEL A 7% REGIME 1

Table C4

Computerisation at 65 X,000 Staff at 65 — £'000 — 7% work growth.

Staff Nos	Salaries	other non-computer Expenses	Computers	Computer Factor	YR
X x 1000	4,602	4,602	13,668	3	65
1060	4,764	5,282	8,812	2	66
1113	5,138	5,820	8,628	2	67
1158	5,313	6,228	12,288	3	68
1204	5,525	6,859	7,778	2	69
1252	5,704	7,374	7,290	2	70
1302	5,906	7,622	9,933	3	71
1354	6,228	7,561	6,260	2	72
1408	6,280	9,151	5,718	2	73
1465	6,761	10,117	7,326	3	74
1523	7,065	11,893	3,866	2	75
1584	7,602	12,065	3,428	2	76
1648	7,184	11,286	4,374	3	77
1713	7,642	11,227	2,704	2	78
1782	7,602	10,941	2,338	2	79
1853	8,079	10,201	3,000	3	80
Totals	101,395 X +	139,229 X +	107,411		

Cumulative Total = 240,624 X + 107,411

MODEL A 7% REGIME 2

Table C5

Computerisation at 70 X,000 Staff at 65 — £'000 — 7% work growth.

Staff Nos	Salaries	other non-computer Expenses	Computers	Computer Factor	YR
X x 1000	4,602	4,602		-	65
1070	4,809	5,332		-	66
1145	5,285	5,987		-	67
1225	5,622	6,599		-	68
1311	6,016	7,469		-	69
1403	6,392	8,264	10,935	3	70
1487	6,745	8,705	6,622	2	71
1561	7,181	9,870	6,260	2	72
1624	7,243	10,554	8,577	3	73
1689	7,795	11,664	4,884	2	74
1756	8,146	13,713	3,866	2	75
1826	8,763	13,909	5,142	3	76
1899	8,278	13,004	2,916	2	77
1975	8,810	12,944	2,704	2	78
2055	8,767	12,618	3,507	3	79
2136	9,313	11,759	2,000	2	80
Totals	113,767 X	157,043 X	57,413		

Cumulative Total = 270,810 X + 57,413

MODEL A 7% REGIME 3

Table C6

Computerisation at 75 X,000 Staff at 65 — £'000 — 7% work growth.

Staff Nos	Salaries	other non-computer Expenses	Computers	Computer Factor	YR
X x 1000	4,602	4,602		-	65
1070	4,809	5,332		-	66
1145	5,285	5,987		-	67
1225	5,622	6,599		-	68
1311	6,016	7,469		-	69
1403	6,392	8,264		-	70
1501	6,809	8,787		-	71
1606	7,388	10,155		-	72
1718	7,662	11,165		-	73
1838	8,482	12,693		-	74
1967	9,125	15,360	5,799	3	75
2085	10,006	15,881	3,428	2	76
2189	9,542	14,990	2,916	2	77
2278	10,162	14,930	4,056	3	78
2368	10,102	14,540	2,338	2	79
2463	10,739	13,559	2,000	2	80
Totals	122,743 X +	170,319 X +	20,537		

Cumulative Total = 293,062 X + 20,537

MODEL A 7% REGIME 4

Table C7

Computerisation X,000 Staff at 65 — 7% work growth.

Staff Nos	Salaries	other non-computer Expenses	Computers	Computer Factor	YR
X x 1000	4,602	4,602		-	65
1070	4,809	5,332		-	66
1145	5,285	5,987		-	67
1225	5,622	6,599		-	68
1311	6,016	7,469		-	69
1403	6,392	8,264		-	70
1501	6,809	8,787		-	71
1606	7,388	10,155		-	72
1718	7,662	11,165		-	73
1838	8,482	12,693		-	74
1967	9,125	15,360		-	75
2105	10,102	16,034		-	76
2252	9,816	15,422		-	77
2410	10,751	15,795		-	78
2579	11,002	15,835		-	79
2759	12,029	15,188		-	80
Totals	125,892 X +	174,693 X			

Cumulative Total = 300,585 X

SUPPOSED YEAR OF COMMENCEMENT OF COMPUTERISATION

65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1000	1150	1323	1521	1749	2011	2313	2660	3059	3518	4045	4652	5350	6153	7076	8137
1120	1288	1482	1704	1960	2252	2591	2979	3426	3940	4530	5210	5992	6891	7925	
1220	1404	1615	1857	2134	2455	2824	3247	3734	4295	4938	5679	6531	7511		
1293	1488	1712	1968	2262	2603	2993	3442	3958	4553	5234	6020	6928			
1345	1548	1781	2047	2352	2707	3113	3580	4116	4735	5443	6262				
1399	1610	1852	2129	2447	2815	3238	3723	4281	4924	5661					
1455	1674	1926	2214	2544	2928	3368	3872	4452	5121						
1513	1741	2003	2303	2646	3045	3503	4027	4630							
1574	1810	2083	2395	2752	3167	3642	4189								
1637	1882	2166	2490	2862	3294	3787									
1702	1958	2253	2590	2977	3425										
1770	2035	2343	2694	3096											
1841	2118	2437	2803												
1914	2203	2534													
1991	2290														
2070															

STAFF REQUIREMENTS WITH 15% WORK GROWTH

Annual Growth Rate	
No Computerisation	15% p.a.
FIRST YEAR	12%
SECOND YEAR	9%
THIRD YEAR	6%
SUBSEQUENT YEARS	4%

Table C8

MODEL A 15% REGIME 1

Computerisation at 1965 at 1980 prices 15% work growth Table C9

Staff Nos	Salaries	£'000 Expenses	£'000 Computers	Computer Factor	YR
1000	4,602	4,602	13,668	3	65
1120	5,033	5,581	8,812	2	66
1220	5,631	6,379	8,628	2	67
1293	5,932	6,954	12,288	3	68
1345	6,172	7,663	7,778	2	69
1399	6,374	8,240	7,290	2	70
1455	6,600	8,517	9,933	3	71
1513	6,960	9,567	6,260	2	72
1574	7,020	10,229	5,718	2	73
1637	7,555	11,305	7,326	3	74
1702	7,896	13,291	3,866	2	75
1770	8,494	13,482	3,428	3	76
1841	8,025	12,607	4,374	3	77
1914	8,538	12,544	2,704	2	78
1991	8,494	12,225	2,338	2	79
2070	9,025	11,395	3,000	3	80

Total X x 112,351 + X x 154,581 + 107,411

Cumulative Total 112,351 X + 154,581 X + 107,411

MODEL A 15% REGIME 2

Computerisation at 1970 at 1980 prices 15% work growth Table C10

Staff Nos	Salaries	£'000 Expenses	£'000 Computers	Computer Factor	YR
1000	4,602	4,602		-	65
1150	5,168	5,730		-	66
1323	6,107	6,918		-	67
1521	6,978	8,180		-	68
1749	8,026	9,964		-	69
2011	9,162	11,845	10,935	3	70
2252	10,215	13,183	6,622	2	71
2455	11,293	15,523	6,260	2	72
2603	11,609	16,917	8,577	3	73
2707	12,493	18,695	4,884	2	74
2815	13,059	21,982	3,866	2	75
2928	14,051	22,302	5,142	3	76
3045	13,273	20,852	2,916	2	77
3160	14,128	20,757	2,704	2	78
3294	14,052	20,225	3,507	3	79
3425	14,933	18,855	2,000	2	80
Total	169,149X	236,530X	57,413		

Cumulative Total 57,413 + 236,530X + 169,149X

MODEL A 15% REGIME 3

Computerisation at 1975 at 1980 prices 15% work growth Table C11

Staff Nos	£'000 Salaries	£'000 Expenses	£'000 Computers	Computer Factor	YR
1000	4,602	4,602		-	65
1150	5,168	5,730		-	66
1323	6,107	6,918		-	67
1521	6,978	8,180		-	68
1749	8,026	9,964		-	69
2011	9,162	11,845		-	70
2313	10,492	13,540		-	71
2660	12,236	16,819		-	72
3059	13,643	19,880		-	73
3518	16,235	24,295		-	74
4045	18,765	31,587	5,799	3	75
4530	21,739	34,505	3,428	2	76
4938	21,525	33,815	2,916	2	77
5234	23,349	34,304	4,056	3	78
5443	23,220	33,420	2,338	2	79
5661	24,682	31,164	2,000	2	80
Total	225,929X	320,568X	20,537		

Cumulative Total 20,537 + 320,568X + 225,929X

MODEL A 15% REGIME 4

No Computerisation : at 1980 prices 15% work growth Table C12

Staff Nos	£'000 Salaries	£'000 Expenses	YR
1000	4,602	4,602	65
1150	5,168	5,730	66
1323	6,107	6,918	67
1521	6,978	8,180	68
1749	8,026	9,964	69
2011	9,162	11,845	70
2313	10,492	13,540	71
2660	12,236	16,819	72
3059	13,643	19,880	73
3518	16,235	24,295	74
4045	18,765	31,587	75
4652	22,325	35,434	76
5350	23,321	36,637	77
6153	27,449	40,327	78
7076	30,186	43,447	79
8137	35,477	44,794	80
Total	250,172X	353,999X	

Cumulative Total 353,999X + 250,172X

TABLE C13 TAX ON COMPANY PROFITS

YR TO 31ST MARCH OF	RATE OF TAX %	YEAR JAN - DEC	EQUIVALENT TAX RATE %	BALANCE AFTER TAX
65	40			
66	40	65	40	60
67	40	66	40	60
68	42.5	67	42	58
69	45	68	44.5	55.5
70	42.5	69	43	57
71	40	70	40.5	59.5
72	40	71	40	60
73	40	72	40	60
74	52	73	49	51
75	52	74	52	48
76	52	75	52	48
77	52	76	52	48
78	52	77	52	48
79	52	78	52	48
80	52	79	52	48
81	52	80	52	48

Data for 65 - 73 from "Revenue Law" B Pinson.
Sweet & Maxwell 1974.

TABLE C14 Cumulative Tax Relief on Computer Costs,
Spread over 7 years (FIGURES ARE x7 IN EACH CASE)

	REGIME 1			REGIME 2			REGIME 3		
YR	7 x OFF-SET AT YEAR	TAX RELIEF AT YEAR	TAX RELIEF AT '80 PRICES	7 x OFF-SET AT YEAR	TAX RELIEF AT YEAR	TAX RELIEF AT '80 PRICES	7 x OFF-SET AT YEAR	TAX RELIEF AT YEAR	TAX RELIEF AT '80 PRICES
65	3	1.2	5.5						
66	5	2.0	8.8						
67	7	2.9	12.5						
68	10	4.5	18.4						
69	12	5.2	20.2						
70	14	5.7	20.8	3	1.2	4.4			
71	17	6.8	22.5	5	2.0	6.6			
72	16	6.4	20.0	7	2.8	8.8			
73	17	8.3	23.7	10	4.9	14.0			
74	18	9.4	23.0	12	6.2	15.1			
75	16	8.3	16.0	14	7.3	14.1	3	1.6	3.1
76	17	8.8	15.1	17	8.8	15.1	5	2.6	4.5
77	18	9.4	13.7	16	8.3	12.1	7	3.6	5.2
78	16	8.3	11.2	17	8.8	11.9	10	5.2	7.0
79	17	8.8	10.3	18	9.4	11.0	12	6.2	7.2
80	18	9.4	9.4	16	8.3	8.3	14	7.3	7.3
DISCOUNTED	5.5	2.9	2.9	5.4	2.8	2.8	5.2	2.7	2.7
81	14			14			14		
82	12			12			11		
83	10			9			9		
84	7			7			7		
85	5			5			6		
86	3			2			2		
TOTAL REDUCTION ON CUMULATIVE COMPUTER COSTS			£36m			£18m			£ 5m
NET CUMULATIVE COMPUTER COSTS			£71m			£39m			£16m

12% Discount Factor	No. of Years discounted
0.89	1
0.80	2
0.71	3
0.64	4
0.57	5
0.51	6

APPENDIX D

Decimalisation of the Currency : A case-study in computer costs.

The Banks and the country were warned years in advance that the currency would be decimalised on 15th February 1971. This was not seen as a major economic change, although it involved a considerable change in habit and required a mass education campaign.

However, for Banks and other institutions keeping customer accounts, a major workload was added to staff. The Banks, involved also in money transmission, required a special clearing operation in order to close all accounts before the change-over to decimal currency could take place. For this planning started three years ahead. At the same time, the Banks saw the possibilities of using computers to calculate the actual conversion of £.s.d. to decimal, and began investigating the ramifications of the change in their extant computer systems. Since the vast majority of Bank computer systems programs contain fields involving money amounts, the decimalisation of the currency implied a major systems overhaul altering fields and operations, as well as the amounts themselves. In addition to program changes, decimalisation necessitatedequipment changes throughout the branches of the Banks. Decimalisation therefore presented an opportunity to bring up to date machinery and systems throughout the Banks. The "Special Clearing" occupied the week-end of Thursday 11th to Sunday 14th February, but planning and systems development culminated in that event. This was an early example of an externally imposed systems change, involving considerable preparation and subject to an arbitrary and unavoidable time deadline.

In the Royal Bank alone, 30 systems staff were involved in revamping 450 programs, ranging from 200 instructions to over 100,000, the most complicated being the current account program.

In order to continue operation computer these changes were necessary. It is estimated that these changes involved 10 man years real-time of work, costing about £20,000 in salaries alone at 1971 rates. In addition, revamped programs would be tested by parallel running with the existing system, involving considerable additional cost and elapsed time. In the context of total expenses this cost was not great. The Government could argue that it would be recovered in time with the use of decimal calculation! The writing of an additional program to convert £.s.d. to decimal was a minor task. The main criterion of this program would be that rounding averaged to zero. Rounding instructions were given by the Government.

It is estimated that, for the Royal Bank, the actual changing of amounts at branches would have taken some 2 man years - on the basis of one minute per change, involving retrieving the account details, making the change, preparing input for the computer, and inputing to the computer. In addition, manual preparation of all customer statements, completed by the central computer in 40 hours, printing some 3 million lines, could have taken up to 40,000 man hours - equivalent to over 70 hours of work by typing staff at each of the branches of the Bank. At that time the Royal Bank had 6,200 branch staff. It is recorded that they "would have had to work overtime for at least two weeks to cope."

The actual paper movement on the decimalisation week-end involved some 6 million vouchers from 1,500 branches. Fortunately, in the light of the postal strike of 1971, the Banks employed the security companies to move all vouchers. Certain routes also involved air transport - from the Islands, and to London.

The Post Office strike also posed the threat of delayed vouchers suddenly entering the clearing and aggravating the problem. In the event this did not happen. Over the clearing weekend there was no major mishap (though the London courier got lost in fog for 6 hours), and only one Scottish branch failed to get its clearings to Edinburgh in time. Around 500 staff, full and part-time worked around-the-clock in the three banks, and 70 vehicles were used to carry vouchers to and fro.

Over the three year lead-in there was conversion and replacement of vast quantities of machinery, from accounting and punch tape machine to postal frankers. In this respect, the Clydesdale Bank records an advantage in having come late to computerisation, and having bought at the outset the new convertible machinery. However, it is extremely likely that machinery purchased before 1965 was already due for replacement by 1971.

An important result of the Special Clearing was that it demonstrated the reliability of security companies in delivering clearings. The Banks have as a result continued to use their services and operate very few delivery vans on their own account.

APPENDIX E

Account Types and Systems

A retail bank, at its simplest, has three types of customer account

Loan Accounts

Current Accounts

Deposit Accounts

In fact, all three Scottish banks operate a number of other types of account, but the main principles are those present in the above types.

LOAN ACCOUNT

The simplest account is the Loan Account. This has the following pattern.

* The customer receives a loan, and agrees to make regular repayments including interest.
* The customer pays/does not pay regularly, and appropriate action is taken
* When the loan is fully repaid, payments terminate.

This is a straightforward and easily computerised type of account. There must be kept up to date a main file of all loan accounts, which with each account name and address identifies payment dates, payment amounts, total loan and termination date.

Each day the file is scanned to identify all due payments.

This is compared with all payments received.

Non-matching items are of two types -

no payment, or too little payment,

nondue or excessive payment.

Appropriate action is taken to correct entries.

A paper document of standard format would normally be used to set up a file record, but thereafter required paperwork should be minimal.

CURRENT ACCOUNT

A Current Account is operated by using a cheque book. Money is paid in, in the form of cash, cheques, money orders, bank giro etc, and is withdrawn by the account holder writing out a cheque to the payee or himself. A person receiving a cheque presents it to his own bank, who will credit his account with the amount. The cheque is passed through the Bank Clearing System, and the payer is eventually debited. The account holder receives statements of his account position from time to time.

On request, his bank will provide him with a Cheque Guarantee Card, which facilitates the use of the cheque book by making the payer's cheques more acceptable. Normally a charge is made for the clearing of the cheque by the bank, though this differs in different banks in different circumstances. A current account can become overdrawn - i.e. the account holder can write cheques for more money than is in his account. Account holders perceive several advantages over cash or other types of account. e.g.:-

(1) There is usually a delay in presenting cheques for payment at a bank, and invariably there is a delay due to the clearing process. This gives a cash flow advantage by delaying the debiting of the payer's account.

(2) Cheques are very widely accepted.

(3) A cheque can be written at any time, and for any amount.

There are disadvantages.

(4) It is not usually possible to be certain of the state of the account - cheques may not have been presented for payment, charges may have been deducted, etc.

(5) There is a danger of fraudulent use of a cheque book if it is lost or stolen, particularly if a cheque guarantee card is with it.

The Clearing operation was originally very labour-intensive and was automated at an early stage in each bank. The full computerisation of current accounting followed.

DEPOSIT ACCOUNTS

Deposit Accounts are thought of by the Banks as a savings vehicle, and also as a new customer's best introduction to banking. When a deposit account is started, the customer is given a pass book, which is literally his key to his account. Transactions can take place without the pass book - standing orders can be paid out, receipts can be accepted - but no cash payment will be made by a branch without production of the passbook. Deposits can be made in person at any bank branch, but the amount that can be withdrawn is restricted at other than the account holding branch. Interest is paid on the balance in the account. On presentation at the issuing branch, the pass book is updated to include any transactions which have occurred since the last presentation of the pass book.

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The pass book is therefore virtually an up-to-date record of the account. A deposit account does not normally become overdrawn. It is also extremely safe, because of the regular referral to home branch, and the limitations put on its use at other branches. It cannot be used, for example, at another bank. There is no equivalent to the cheque guarantee card.

GENERAL

Current Accounts and Deposit Accounts both require file back-up. This can be automatic, or paper-based, or a combination. In addition certain information is required at each transaction as follows:-

Main File Record. - Deposit / Current Account.

Name(s) of customer

Addresses

Type of account

Amount in Credit / Debit

Allocated account number

Branch name, address

Date

Type of statement

Mode of operation

Standing Order / Direct Debit details

Cross reference to other accounts held by customer (optional)

Transaction data - credit

Name of receiving account

Address of receiving account (bank address)

Number of receiving account

Amount

Date

Form of payment

Transaction data - debit

Payee name and other optional information

Payer name

Payer account number

Payer bank address

Amount

Date

Form of payment

These data requirements have changed only marginally since the inception of the deposit and current account.

The introduction of the cheque guarantee card involves the additional requirement, before posting a cheque at a branch, of evidence of card use. This is normally in the form of the card number endorsed on the reverse of the cheque by the payee. A guaranteed cheque cannot be refused for any reason.

General Ledgers

Alongside the development of Customer Accounting Systems has been the computerisation of Branch General Ledger Accounts.

The General Ledgers of a Branch are the summaries of all customer data as it affects the branch, and in addition, the accounting of the general financial management of the Branch. One input to the General Ledgers is, therefore, derivable from customer account data, and as such can in theory be found directly from the customer accounting system. Thus, though distinct from customer accounting, development in this area has been, inevitably, influenced by customer accounting.

The General Ledgers reflect the aspect of the branch as a business, like any other enterprise, and will have titles like the following:

G.L. Current Accounts - showing as a positive or negative figure the total in current accounts at the branch

G.L. Deposit Accounts - similar.

G.L. Deposit Receipts.

G.L. Term Loans.

G.L. Revenue Account.

G.L. Local Clearing.

G.L. Cash.

and so on.

Each branch will have perhaps 15 or 20 such accounts.

These accounts are of particular interest to the Chief Accountant of the Bank, because it is from these that an overall picture of the running of the Bank can be gained. In spite of the fact that General Ledgers were automated very early in the development of computerisation, the logical continuation of this into the Chief Accountant's Department has only recently been undertaken. One very strong reason for this delay is security.

The General Ledgers for the Bank as a whole will contain information that is highly sensitive in terms of competition with other Banks. The Chief Accountant has as a result a distinct preference to have this sensitive data under his own control on a mini-computer - only a recently available development.

APPENDIX F

IDENTIFICATION OF ERROR TYPES

First examination produces a list of missing values and additional values. These constitute the two sides of the "UNPAIRED POOL". A proportion of these values can be matched off as misread items. These misreads will take one of three forms:

MISPUNCH - ONE DIGIT DIFFERENT, OR PENCE DIGITS DIFFERENT

INVERSION - TWO ADJACENT DIGITS ARE INVERTED, OR TWO SEPARATED BY ONE DIGIT ARE INVERTED.

TRANSLATION - THE COMPLETE SEQUENCE OF NUMBERS IS MOVED ONE OR TWO SPACES TO LEFT OR RIGHT

It is assumed that a combination of these errors will not be identified as a misread, but will be listed as a missing plus an over.

In proposing that a misread can be correctly identified as such, it is important to know the probability that one batch will contain a missing cheque and an over cheque, which bear one of the misread relations to each other.

To calculate this, it is assumed

1. That a cheque will be value encoded as

   £ A,BCD,EFG,HJ

   with these letters taking one of the ten values 0 to 9.

2. That cheques within a batch are selected randomly from an infinite cheque population which has a probability distribution as follows:-

RANGE	VALUE RANGE	PROBABILITY CHEQUE IS WITHIN RANGE
A	0 - 99p	0.02
B	£1 - 9.99	0.40
C	10 - 99.99	0.48
D	100 - 999.99	0.08
E	1000 +	0.02

This is based on an analysis of the cheques passing through the clearing done by IBRO.

3. That batches of 250 cheques have at least one cheque MISSING with a probability of 0.23, and have at least one cheque OVER with a probability of 0.09.

These are high estimates, and since many batches contain fewer than 250 cheques, the final calculations are on the high side. With these assumptions it is found that, the probability that a MISSING cheque and an OVER cheque in the same batch are identified as a MISREAD is

p (NOT TRANSLATION WHEN SO IDENTIFIED) 1.3×10^{-5}

\+ p (NOT MISPUNCH WHEN SO IDENTIFIED) 12.7×10^{-5}

\+ p (NOT INVERSION WHEN SO IDENTIFIED) 1.4×10^{-5}

Hence the total probability that a MISSING cheque and an OVER cheque in the same batch are mis-identified as a MISREAD is of the order of 15.4×10^{-5}. THIS IS DOMINATED BY ONE MISPUNCH CONDITION. EXCLUDING THIS, THE PROBABILITY IS OF THE ORDER OF 5.8×10^{-5}.

MISPUNCH CONDITION : ASSUMPTIONS

1. Within any one of the 5 specified value ranges, all values are equally likely. Although this is not strictly true, it is not likely to cause an underestimate of the probabilities involved. (This is allowed for in the fifth band in the calculations).
2. Let X = Prob (Missing cheque in range R)
   Y = Prob (over cheque in another range S)
   K = No. of ways a cheque in range S can be a mispunch for a cheque in range R.
   Q = Probability of an identified digit having a specified value (zero or non-zero)
   W = Actual number of values in range S.
   L = Probability that a MISSING cheque in range R is identified as an OVER cheque in range S.
   L = P = Probability that a MISSING cheque in all ranges is identified with an OVER cheque in all ranges.

3. A MISPUNCH condition can appear either when an incorrect digit is actually encoded, or when the MICR printing is not of correct readable quality. In the latter case, certain misreads are more likely

e.g. 0 read as 6

3 or 5 read as 8 or vice versa etc.

Thss implies that the probabilities calculated allow for more changes than are actually likely to happen. Further work could be done on this but it is not likely to be justified.

4. If an OVER and a MISSING both in the £1 - £9.99 range are excluded as possible MISPUNCHES then the largest proportion of this type of misidentification is eliminated.

If in addition pairs both in the £10 - £99.99 range are excluded as possible MISPUNCHES then the residual error is halved again.

5. Conditions for MISPUNCH:

		p
1)	1 ERROR IN DIGIT COMPARISONS IN 2 RANDOM CHEQUES	6.13×10^{-3}
2)	1 ERROR IN DIGIT COMPARISONS IN 2 RANDOM CHEQUES, CHEQUES BOTH IN RANGES £1 - £9.99 EXCLUDED	0.15×10^{-3}
3)	1 ERROR IN DIGIT COMPARISONS IN 2 RANDOM CHEQUES, CHEQUES BOTH IN RANGE £1 - £99.99 EXCLUDED	0.06×10^{-3}

Based on the data collected, in the worst case where batches contain 250 items, and have the highest incidence of MISREADS, 42.5% of all batches will be expected to show one or more error, either values missing or over. It is reasonable to assume that the events 'MISSING', 'MISREAD' and 'OVER' are independent. Other types of error are immediately identifiable and are therefore not relevant in this discussion. On this basis of independence the 42.5% is distributed as follows

ERROR	% OF BATCHES	
MISSING ONLY (B)	0.172	
OVER ONLY (C)	0.055	0.227
MISREAD ONLY (A)	0.125	
MISSING & MISREAD ONLY (A, B)	0.038	
MISREAD & OVER ONLY (A, C)	0.014	
MISREAD, MISSING & OVER (A,B,C)	0.004	0.181
MISSING & OVER ONLY (B, C)	0.017	0.017
		0.425

Out of all batches, 42.5% will have difference lists containing one of the three error types. 22.7% will have lists containing only missing or only over errors. The remaining 19.8% will have missing values and over values which will require to be sorted out into MISREADS and non-MISREADS. 12.5% will contain MISREADS only.

Raw lists of differences are unlikely to contain more than 2 apparent MISSING or two apparent OVER values. So there is not likely to be a need for testing out more than 4 pairs for MISREAD conditions, within each batch.

So, the number of pairs to be tested is of the order of:

$$4 \times 0.198 \times 1260 = 1{,}000 \text{ pairs.}$$

where 1260 is the average number of batches processed per clearing.

Where there are MISREADS only, i.e. 12.5% of all cases, assuming 2 apparent OVER, and 2 apparent MISSING values, one of the first two pairs will be identified as a MISREAD, and this is likely to occur early in the tests. There remains then only 1 pair to be tested out. Hence in 12.5% cases, only 3 pairs will be tested. This reduces the number of pairs likely to be tested to

$$\begin{matrix} 4 \times 0.073 \times 1260 \\ + 3 \times 0.125 \times 1260 \end{matrix} - 360 + 480 = 840 \text{ pairs}$$

This implies that the total amount of computer time required for testing is very small.

Let $P(A) = 0.18$

$P(B) = 0.23$ A, B, C independent

$P(C) = 0.09$

Then $P(AnB) = 0.0414$

$P(AnC) = 0.0178$

$P(BnC) = 0.0207$

$P(AnBnC) = 0.0037$

So $P(A,\neg B,\neg C) = P(A) - P(A \cap B) - P(A \cap C) + P(A \cap B \cap C)$

$P(B,\neg A,\neg C) = P(B) - P(B \cap A) - P(B \cap C) + P(A \cap B \cap C)$

$P(C,\neg A,\neg B) = P(C) - P(C \cap A) - P(C \cap B) + P(A \cap B \cap C)$

$P(A, B,\neg C) = P(A \cap B) - P(A \cap B \cap C)$

$P(A,\neg B, C) = P(A \cap C) - P(A \cap B \cap C)$

$P(\neg A, B, C) = P(B \cap X) - P(A \cap B \cap C)$

$$P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(A \cap C) - P(B \cap C) + P(A \cap B \cap C)$$

This gives

$P(A,\neg B,\neg C) = 0.18 - 0.0414 - 0.0178 + 0.0037 = 0.1245$

$P(B,\neg A,\neg C) = 0.23 - 0.0414 - 0.0207 + 0.0037 = 0.1716$

$P(C,\neg A,\neg B) = 0.09 - 0.0178 - 0.0207 + 0.0037 = 0.0552$

$P(A, B,\neg C) = 0.0414 - 0.0037 = 0.0377$

$P(A,\neg B, C) = 0.0178 - 0.0037 = 0.0141$

$P(\neg A, B, C) = 0.0207 - 0.0037 = 0.0170$

$P(A \cup B \cup C) = 0.18+0.23+0.09-0.0414 - 0.0178 - 0.0207 + 0.0037 = 0.4238$

CALCULATION OF THE PROBABILITY THAT A TRANSLATION CONDITION EXISTS BETWEEN TWO VALUES IN A' OUTER, WITHOUT A TRANSLATION ACTUALLY TAKING PLACE.

P = Probability

$P(\text{Solved by Translation Conditions}) = \sum_{\text{ALL RANGES}} P(\text{MISSING CHEQUE IN RANGE R}) \times P(\text{OVER CHEQUES IN RANGE R1 OR R2}) \times P(\text{DIGITS MATCH})$

WHERE R IS ONE OF THE FIVE SPECIFIED RANGES, AND R1 OR R2 EITHER ADJACENT OR SAME RANGES.

P(DIGITS MATCH) = NUMBER OF TRANSLATIONS IN RANGE / NUMBER OF POSSIBLE VALUES IN RANGE.

LET X = P(MISSING CHEQUE IN RANGE R)

Y = P(OVER CHEQUE IN RANGES R1, R2)

Z = NUMBER OF TRANSLATIONS IN RANGE

W = NUMBER OF VALUES IN RANGE.

S = PROBABILITY OF A CHEQUE PASSING; (ASSUME 0·2)

T = PROBABILITY OF A CHEQUE EXTRA (ASSUME 0·1)

THEN L = PROBABILITY TWO VALUES TAKEN AT RANDOM FROM AN INFINITE POPULATION ARE RELATED BY TRANSLATION CONDITION.

$$= \sum_{R} X \left[\sum_{\substack{R1 \\ R2}} YZ/W \right] \doteq 6{\cdot}2 \times 10^{-4}$$

AND $P = L \times S \times T \doteq 1{\cdot}28 \times 10^{-5} \doteq 1{\cdot}3 \times 10^{-5}$

RANGE OF VALUES OF MISSING CHEQUES	X PROB IN VALUE RANGE	FROM OF CHEQUE VALUE	FORM OF CHEQUE TRANSLATIONS	RANGE OF VALUES OF POSSIBLE SUBSTITUTIONS	Z NUMBER OF TRANSLATIONS IN RANGE	Y PROB IN VALUE RANGE	W ACTUAL NUMBER OF VALUES IN RANGE	$\sum_{R} X \left[\sum_{\substack{R1 \\ R2}} YZ/W \right]$	= L
£0.99p	0·02	£ 0.HJ	0.0H	< 1	1	0·02	9	$0{\cdot}02 \times [0{\cdot}02 / 9]$	0·0 0 0 0 4 4 4
			H.JO	1 - 10	1	0·40	9×10^2	$+ 0{\cdot}40 \times [0{\cdot}40 / 9 \times 10^2]$	0·0 0 0 0 0 8 9
			HJ.00	10 - 100	1	0·48	9×10^3	$+ 0{\cdot}48 \times [0{\cdot}48 / 9 \times 10^3]$	0·0 0 0 0 0 1 1
£1 - 9·99	0·40	£.HJ	0.0£	< 1	2	0·02	9×10	$+ 0{\cdot}40 \times [2 \times 0{\cdot}02 / 9 \times 10]$	0·0 0 0 0 1 3 7 6
			0.£H					$0{\cdot}48 / 9 \times 10^3 +$	0·0 0 0 0 0 2 1 3
			£H.JO	10 - 100	1	0·48	9×10^3	$0{\cdot}08 / 9 \times 10^4]$	0·0 0 0 0 0 0 3 6
			£H1.00	100 - 1000	1	0·08	9×10^4		
10 - 99·99	0·48	F£.HJ	0.F£	< 1	1	0·02	9×10	$+ 0{\cdot}48 \times [0{\cdot}02 / 9 \times 10 +$	0·0 0 0 1 0 7 2
			F.£H	0 - 10	1	0·40	9×10^2	$0{\cdot}4 / 9 \times 10^2 +$	0·0 0 0 0 2 1 3 3
			F£H.J0	100 - 1000	1	0·08	9×10^3	$0{\cdot}08 / 9 \times 10^3 +$	0·0 0 0 0 0 0 0 4
			F.£H1.00	1000 - 10000	1	0·02	9×10^4	$0{\cdot}02 / 9 \times 10^4]$	0·0 0 0 0 0 0 0 0
100 - 999·99	0·08	EF£.HJ	E.F£	0 - 10	1	0·40	9×10^2	$+ 0{\cdot}08 \times [0{\cdot}4 / 9 \times 10^2 +$	0·0 0 0 0 3 5 6
			EF.£H	10 - 100	1	0·48	9×10^3	$0{\cdot}48 / 9 \times 10^3 +$	0·0 0 0 0 0 4 6 3
			E,F£H.J0	> 1000	2	0·02	$> 10^4$	$0{\cdot}02 / 10^4]$	0·0 0 0 0 0 0 0 0
			EF,£H1.00						
> 1,000	0·02	A,BCD,EF£.HJ	AD,CDB.F£	10 - 100	1	0·48	9×10^3	$+ 0{\cdot}02 \times [0{\cdot}48 / 9 \times 10^3 +$	0·0 0 0 0 0 1 1
			ABC,DEF.£J	100 - 1000	1	0·08	9×10^4	$0{\cdot}08 / 9 \times 10^4 +$	0·0 0 0 0 0 0 0
			A,CDE,F£H.J0	> 1000	2	0·02	$> 10^7$	$0{\cdot}02 / 10^7]$	0·0 0 0 0 0 0 0 0
			C,DEF,£H1.00						
									0·0 0 0 6 1 3 5

Calculation of the Probability that a mismatch condition occurs in two changes between an individual from an infinite population

Range R of values of mismatch changes	X Prob in value range R	Form of change Values	Forms of Mismatch Values	Ranges of Values of Mismatch	No of possible mismatches in range, KR	Y Prob in value range	W Number of values in range	$\sum_R X\left[\sum R K Y / W\right] = L$
≤ 0.99	0.02	0.HZ	0.9Z	≤ 0.99	9	0.02	100	$0.02 \times [18 \times 0.02 / 10^2 +$
			0.HP	≤ 0.99	9			$9 \times 0.4 / 9 \times 10^2 +$
			P.HZ	1 – 10	9	0.40	9×10^2	$9 \times 0.48 / 9 \times 10^3 +$
			PO.HZ	10 – 100	9	0.48	9×10^3	$9 \times 0.08 / 9 \times 10^4 +$
			P00.HZ	100 – 1000	9	0.08	9×10^4	$36 \times 0.02 / 10^6$
			P000.HZ	1000 – 10,000	9	0.02	$> 10^6$	
			P0000.HZ	10,000 – 100,000	9			
			P00000.HZ	100,000 – 1,000,000	9			
			P,000,000.HZ	1,000,000 – 9,999,999	9			
1 – 9.99	0.40	Q.HZ	Q.HP	1 – 9.99	9	0.40	9×10^2	$+ 0.40 \times [26 \times 0.40 / 9 \times 10^2 +$
			Q.PZ	1 – 9.99	9			$0.02 / 10^2 +$
			P.HZ	1 – 9.99	9	0.02	100	$9 \times 0.48 / 9 \times 10^3 +$
			0.HZ	≤ 0.99	9	0.48	9×10^3	$9 \times 0.08 / 9 \times 10^4 +$
			PQ.HZ	10 – 100	9	0.08	9×10^4	$36 \times 0.02 / 10^6$
			P0Q.HZ	100 – 1000	9	0.02	$> 10^6$	
			P,00Q.HZ	1000 – 10000	36			
			P0,00Q.HZ	10,000 +				
			P00,00Q.HZ					
			P,000,00Q.HZ					
10 – 99.99	0.48	PQ.HZ	PQ.HP	10 – 99.99	9	0.48	9×10^3	$+ 0.48 \times [35 \times 0.48 / 9 \times 10^3 +$
			PQ.PZ	10 – 99.99	9			$1 \times 0.9 \times 0.4 / 9 \times 10^2 +$
			PP.HZ	10 – 99.99	9			$1 \times 0.1 \times 0.02 / 10^2 +$
			PQ.HZ P≠0	10 – 99.99	9	0.40	9×10^2	$9 \times 0.08 / 9 \times 10^4 +$
			OQ.HZ Q≠0	1 – 10	1×0.9	0.02	100	$36 \times 0.02 / 10^6$
			00.HZ Q=0	0 – 0.99	1×0.1	0.08	9×10^4	
			PFQ.HZ	100 – 1,000	36	0.02	$> 10^6$	
			P,0FQ.HZ	1,000 +				
			P0,0FQ.HZ					
			P00,0FQ.HZ					
			P,000,0FQ.HZ					
100 – 999.99	0.08	EQ.HZ	EFQ.HP	100 – 1000	9	0.08	9×10^4	$+ 0.08 \times [44 \times 0.08 / 9 \times 10^4 +$
			EFQ.PZ	100 – 1000	9			$1 \times 0.9 \times 0.48 / 9 \times 10^3 +$
			EFP.HZ	100 – 1000	9			$1 \times 0.1 \times 0.9 \times 0.4 / 9 \times 10^2 +$
			EPQ.HZ	100 – 1000	9			$1 \times 0.1 \times 0.1 \times 0.2 / 10^2 +$
			PEQ.HZ P≠0	100 – 1000	9	0.48	9×10^3	$36 \times 0.2 / 10^6$
			OFQ.HZ F≠0	10 – 100	9×0.9	0.40	9×10^2	
			0DQ.HZ P=0,Q≠0	1 – 10	$1 \times 0.1 \times 0.9$	0.02	100	
			000.HZ P=0,Q=0	< 1	$1 \times 0.1 \times 0.1$	0.02	$> 10^6$	
			P,EFQ.HZ	1,000 +	36			
			P0,EFQ.HZ					
			P00,EFQ.HZ					
			P,000,EFQ.HZ					
≥ 1,000	0.02	0,EFQ.HZ	0,EFQ.HP	≥ 1000	9	0.02	9×10^5	$+ 0.02 \times [53 \times 0.02 / 9 \times 10^5 +$
			0,EFQ.PZ		9			$1 \times 0.9 \times 0.08 / 9 \times 10^4 +$
			0,EFP.HZ		9			$1 \times 0.1 \times 0.9 \times 0.48 / 9 \times 10^3 +$
			0,EPQ.HZ		9			$1 \times (0.1)^2 \times 0.9 \times 0.4 / 9 \times 10^2 +$
			0,FFQ.HZ		9			$1 \times (0.1)^3 \times 0.02 / 10^2 +$
			P,EFQ.HZ		9			$27 \times 0.02 / 10^6$
			0,EFQ.HZ P≠0		1×0.9	0.08	9×10^4	
			0,EFQ.HZ P=0,E≠0	100 – 1000	$1 \times 0.1 \times 0.9$	0.48	9×10^3	
			0,EFQ.HZ P=0,E=0,F≠0	10 – 100	$1 \times (0.1)^2 \times 0.9$	0.40	9×10^2	
			0,EFQ.HZ P=0,E=0,F=0,Q≠0	1 – 10	$1 \times (0.1)^3$	0.02	100	
			0,000,HZ P=0,E=0,F=0,Q=0	< 1	9	0.02	$> 10^6$	
			P0,EFQ.HZ	≥ 1000	9			
			P00,EFQ.HZ		9			
			P,000,EFQ.HZ		9			

$$P = \sum_S L = 0.0061258$$

$0.0061258 = 0.09 \times 0.23 \times 0.852808 \times 0$

$= 12.7 \times 10^{-5}$

≥ 1,000 Probabilities not calculated as these are negligible

Partial Translation

e.g. 9,000,000.56 written as 900,000.56

can only happen for two very large values (£1,000.00). It requires one or two zeros to be missed out or added; and for the condition to appear randomly, the probability is of the order of 10^{-6} or less.

It requires both numbers to contain several zeros consecutively.

Inversion:

Calculation of the Probability that an Inversion condition appears in two cheques taken at random from the infinite population

Requirements: Both cheques are in the same range.

All digits are the same except for two adjacent digits which are inverted, or two digits separated by one digit only, which are inverted.

Range	Possible no. of inversion pairs adjacent	Possible no. of inversion pairs non-adjacent	Probability P both in range	No. of values in range	Q Chance of Inversion Condition	P x Q
A	1		$(0.02)^2$	99	1/99	0.000004
B	2	1	$(0.40)^2$	$9x10^2$	$3/9x10^2$	0.000533
C	3	2	$(0.48)^2$	$9x10^3$	$5/9x10^3$	0.000128
D	4	3	$(0.08)^2$	$9x10^4$	$7/9x10^4$	0.000000
E	5	4	$(0.02)^2$	$9x10^5$	$9/9x10^5$	0.000000
	6	5		$9x10^6$	$11/9x10^6$	
	7	6		$9x10^7$	$13/9x10^7$	
	8	7		$9x10^8$	$15/9x10^8$	

Probability two cheques are in same range and inversion conditions hold = PQ 6.7×10^{-4}

In a batch of cheques

So Probability that in a batch of cheques, there is at least one MISSING and at least one OVER, and they are related by inversion is

S T x PQ = $6.7 \times 10^{-4} \times 0.23 \times 0.09 = 1.4 \times 10^{-5}$

Notes

1. MISPUNCH - to minimize possibility of misidentification, MISPUNCH could be deemed not to hold if both values are in the ranges £1 - 9.99 or £10 - 99.99, or in the one range £1 - 99.99. However, even if these are allowed as MISPUNCH, the chance of error in identification is still low.
2. Translation, Partial Translation or Inversion

   If two numbers are related by one of these conditions, then their difference will be exactly divisible by 9. The converse does not hold. (e.g. 11 - 2 = 9 and these two numbers are not so related).

   A second order translation is also divisible by 99 (though the converse does not hold).

APPENDIX G : DIFFERENCE STATISTICS (see Chapter 8.2)

TABLE G.1

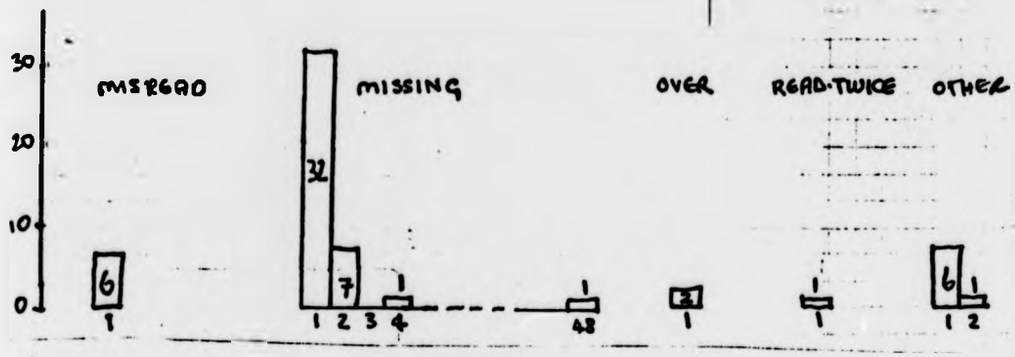
SAMPLES A

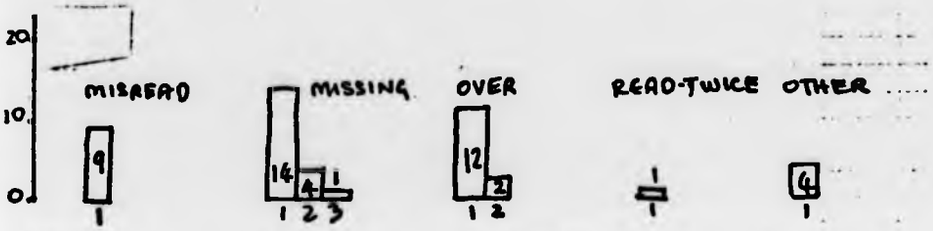
DEBIT CLEARING DIFFERENCES

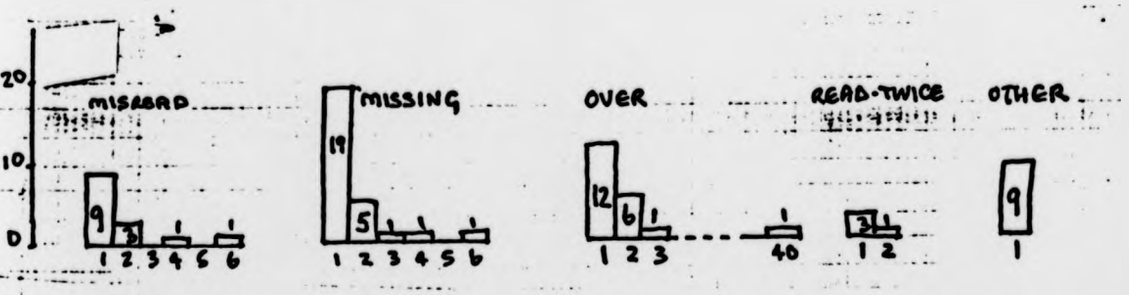
	TOTAL OF CHEQUES	TOTAL MISREAD	TOTAL MISSING	TOTAL OVER	TOTAL READ-TWICE	TOTAL OTHER	GRAND TOTAL
1	17,300	6	98	2	1	8	115
2	15,500	9	25	16	1	4	55
3	20,600	25	42	67	5	9	148
4	20,920	14	68	44	13	9	148
	ERROR PROPORTIONS: ALL FIGURES x 10^{-4}						
1		3.468	56.647	1.156	0.578	4.624	66.474
2		5.788	16.077	10.289	0.643	2.572	35.370
3		12.136	20.388	32.524	2.427	4.369	71.845
4		6.692	32.505	21.033	6.214	4.302	70.745
TOTAL: 466		74,320	54	233	129	20	30
STRATIFIED PROPORTION AVERAGE 62.702			7.266	31.351	17.357	2.691	4.037
NUMBER OF BATCHES WITH ERRORS:							
1		6	41	2	1	7	
2		9	19	14	1	4	
3		14	27	20	4	9	
4		12	37	26	6	9	
	ASSUMPTION: BATCH SIZE 75. PROPORTION WITH ERRORS						
1	231	0.0260	0.1775	0.6087	0.0043	0.0303	
2	207	0.0435	0.0918	0.0676	0.0048	0.0193	
3	275	0.0509	0.0982	0.0727	0.0145	0.0327	
4	279	0.0430	0.1326	0.0932	0.0215	0.0323	
TOTALS:	992		41	124	62	12	29
STRATIFIED PROPORTION AVERAGE	0.0413		0.125	0.0625	0.0121	0.0292	
	HARD-CORE DIFFERENCES (NOT CLEARED AFTER 6 WEEKS)						
1		0	1	0	0	0	
2		0	3	6	0	0	
3		1	2	2	0	0	
4		1	12	15	0	5	

SAMPLES A

VERTICAL : FREQUENCY
HORIZONTAL : NO OF GROUPS OF THAT TYPE IN BATCH







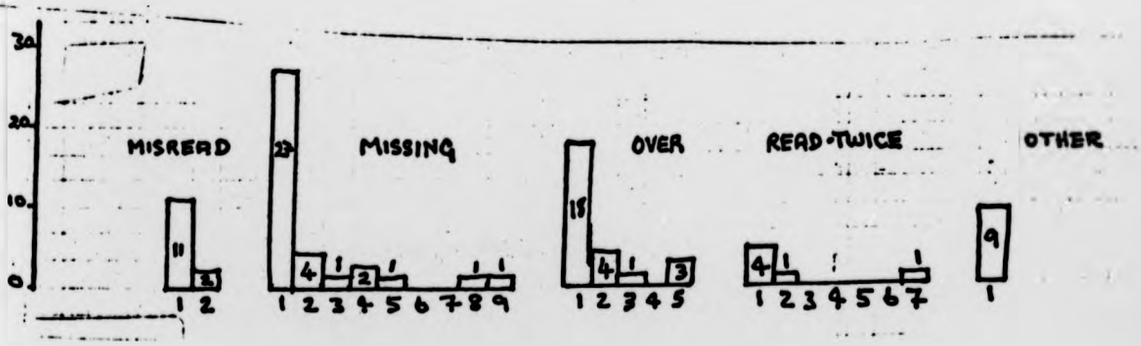
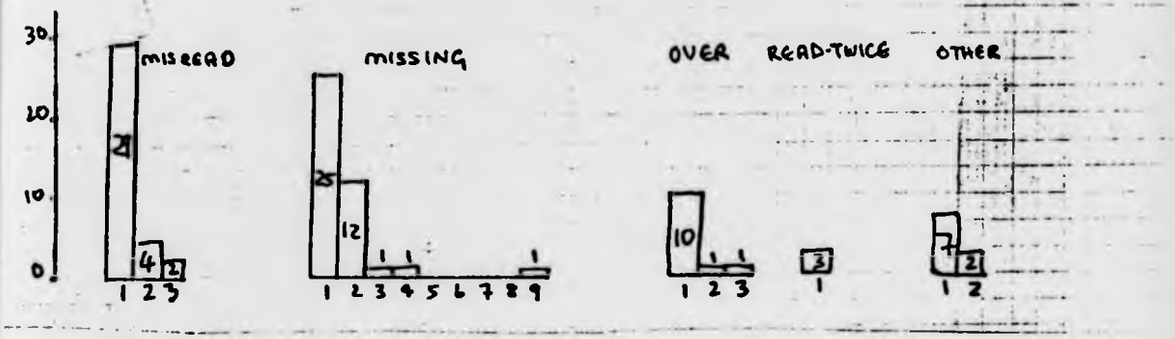


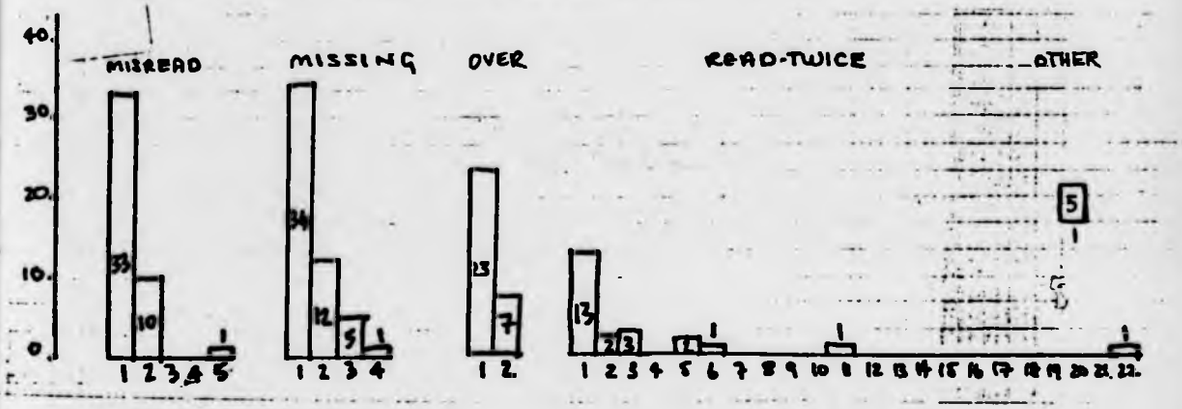
TABLE G.2

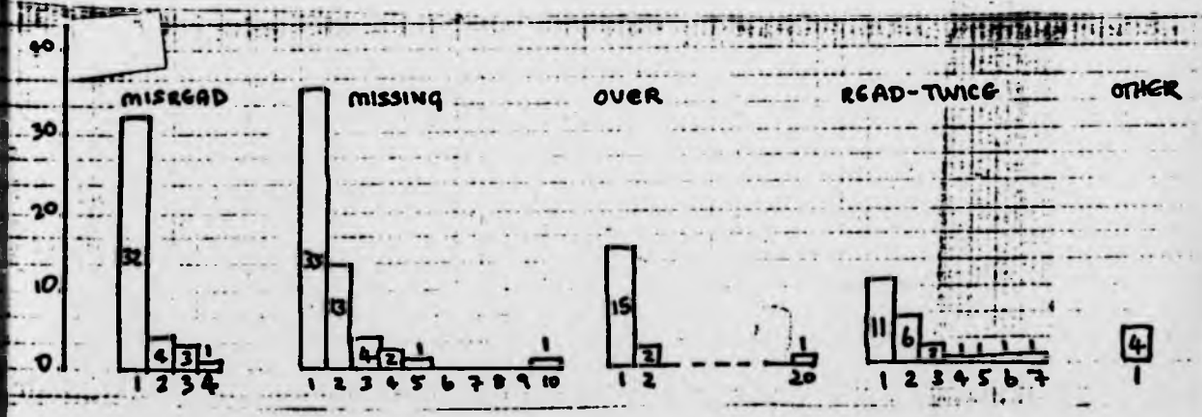
SAMPLES B
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL MISREAD	TOTAL MISSING	TOTAL OVER	TOTAL READ-TWICE	TOTAL OTHER	GRAND TOTAL
1	41,300	43	65	15	3	11	137
2	36,800	58	77	37	72	5	249
3	49,200	53	96	39	51	4	243
4	50,090	40	48	15	59	4	166
	ERROR PROPORTIONS: ALL FIGURES x 10^{-4}						
1		10.437	15.777	3.641	0.728	2.670	33.252
2		15.761	20.924	10.054	19.565	1.359	67.663
3		10.772	19.512	7.927	10.366	0.813	49.390
4		7.986	9.583	2.995	11.779	0.799	33.140
TOTAL:	177,290	194	286	106	185	24	795
STRATIFIED PROPORTION AVERAGE		10.943	16.132	5.979	10.435	1.354	44.842
NUMBER OF BATCHES WITH ERRORS:							
1		35	40	12	3	9	
2		44	52	30	23	5	
3		40	56	18	23	4	
4		27	36	10	17	4	
	ASSUMPTION: BATCH SIZE 250.			PROPORTION WITH ERRORS			
1	165	0.2121	0.2424	0.0727	0.0182	0.0545	
2	147	0.2993	0.3537	0.2041	0.1565	0.0340	
3	197	0.2030	0.2843	0.0914	0.1168	0.0203	
4	200	0.1350	0.1800	0.0500	0.0850	0.0200	
TOTALS:	709	146	184	70	66	22	
STRATIFIED PROPORTION AVERAGE		0.2059	0.2595	0.0987	0.0931	0.0310	
	HARD-CORE DIFFERENCES (NOT CLEARED AFTER 6 WEEKS)						
1		0	0	2	0	1	
2		1	0	0	1	0	
3		0	3	1	3	0	
4		7	7	6	0	1	

SAMPLES B


MISREAD
MISSING
OVER
READ-TWICE
OTHER


MISREAD
MISSING
OVER
READ-TWICE
OTHER


MISREAD
MISSING
OVER
READ-TWICE
OTHER

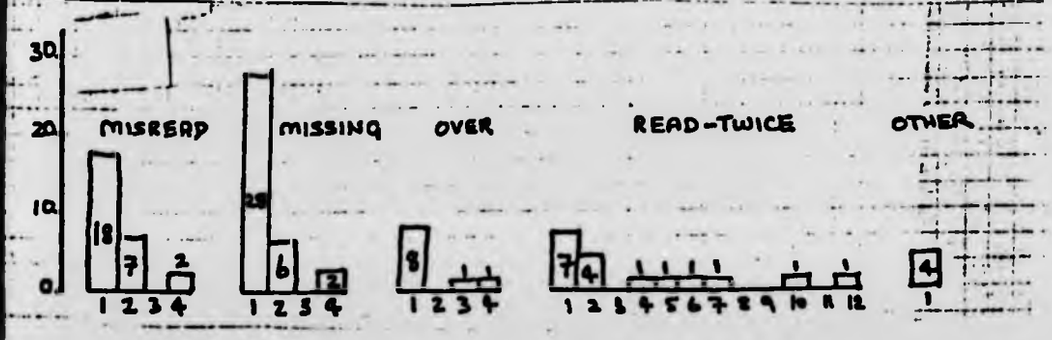
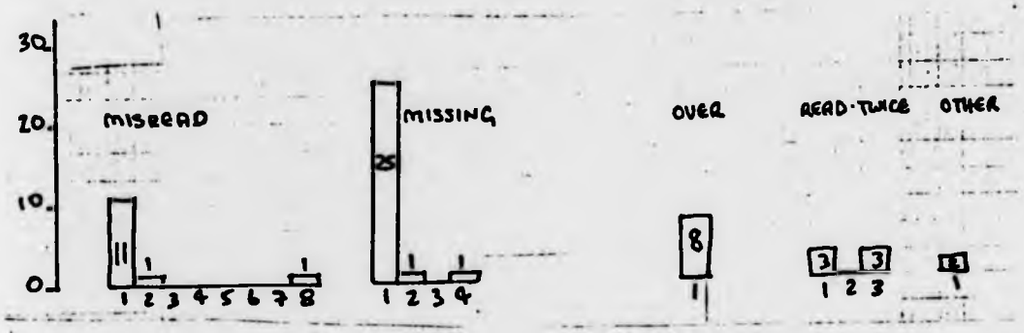

MISREAD
MISSING
OVER
READ-TWICE
OTHER

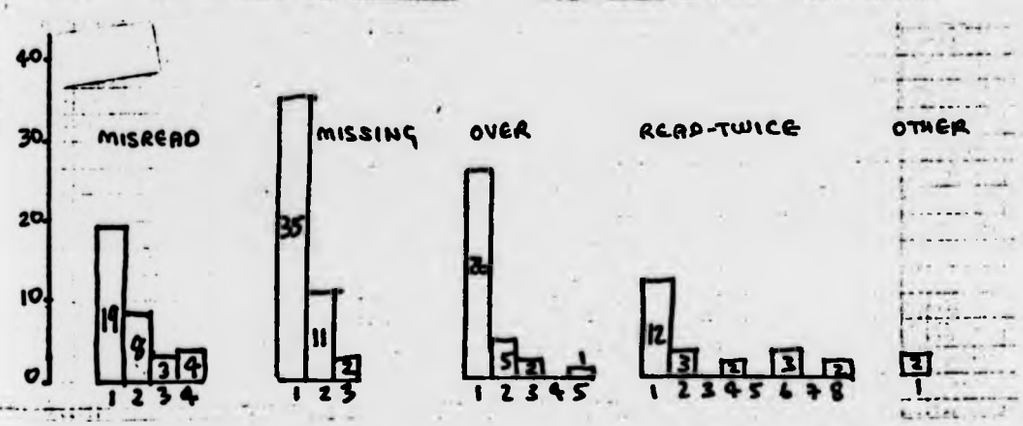
TABLE G.3

SAMPLES C
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL MISREAD	TOTAL MISSING	TOTAL OVER	TOTAL READ-TWICE	TOTAL OTHER	GRAND TOTAL
1	41,700	21	31	8	12	2	74
2	37,200	60	63	47	60	2	232
3	49,800	46	72	8	21	5	152
4	50,700	25	37	6	9	3	80
	ERROR PROPORTIONS: ALL FIGURES x 10^{-4}						
1		5.036	7.434	1.919	2.878	0.480	17.746
2		16.129	16.936	12.634	16.129	0.538	62.366
3		9.237	14.458	1.606	4.217	1.004	30.522
4		4.931	7.298	1.183	1.775	0.592	15.779
TOTAL:	179,400	152	203	69	102	12	538
STRATIFIED PROPORTION AVERAGE		8.473	11.316	3.846	5.686	0.669	29.989
NUMBER OF BATCHES WITH ERRORS:							
1		13	27	8	6	2	
2		34	48	34	22	2	
3		27	44	17	10	5	
4		14	24	6	5	3	
	ASSUMPTION: BATCH SIZE 200.			PROPORTION WITH ERRORS			
1	209	0.0622	0.1292	0.0383	0.0287	0.0096	
2	186	0.1828	0.2581	0.1828	0.1183	0.0108	
3	249	0.1084	0.1767	0.0281	0.0402	0.0201	
4	254	0.0551	0.0945	0.0236	0.0197	0.0118	
TOTALS:	898	88	143	55	43	12	
STRATIFIED PROPORTION AVERAGE		0.0980	0.1592	0.0612	0.0479	0.0134	
	HARD-CORE DIFFERENCES (NOT CLEARED AFTER 6 WEEKS)						
1		0	1	1	0	0	
2		0	1	6	1	3	
3		0	1	1	1	0	
4		3	1	0	2	0	

SAMPLES C


30
20
10
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER
11
1
1
25
1
1
8
3
3
1
1 2 3 4 5 6 7 8
1 2 3 4
1
1 2 3
1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MISREAD
MISSING
OVER
READ-TWICE
OTHER
19
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4
35
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2
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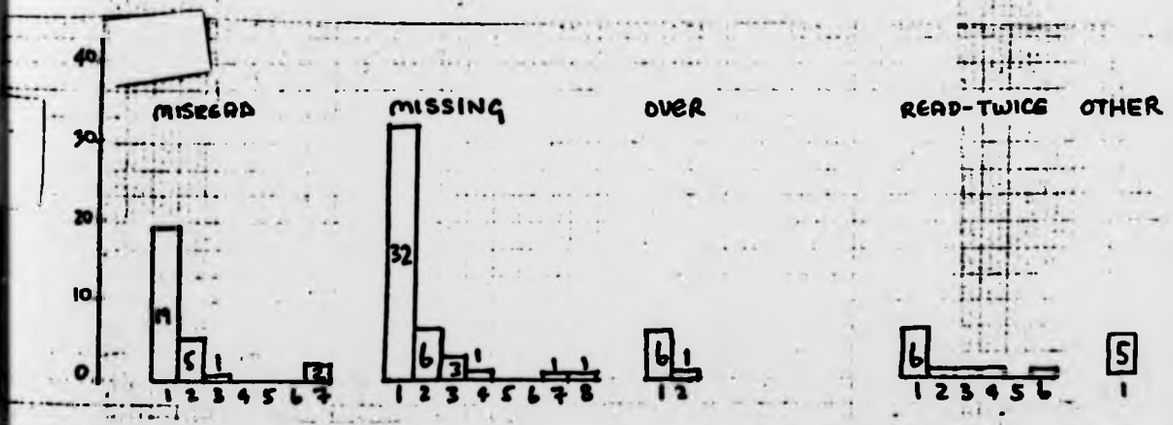
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OVER
READ-TWICE
OTHER
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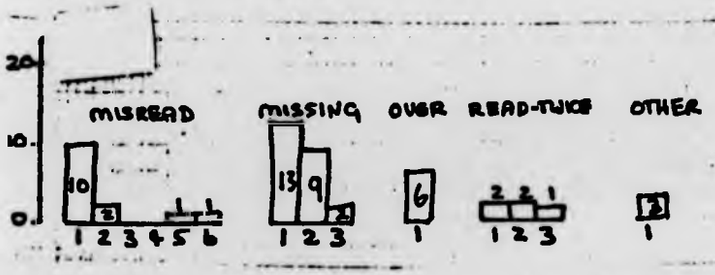
1 2 3 4 5 6
1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MISREAD
MISSING
OVER
READ-TWICE
OTHER
10
3
1
1
13
9
2
6
2
2
1
3
1 2 3 4 5 6
1 2 3
1
1 2 3
1

TABLE G.4

SAMPLES D
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL MISREAD	TOTAL MISSING	TOTAL OVER	TOTAL READ-TWICE	TOTAL OTHER	GRAND TOTAL
1	13,550	13	31	3	5	3	55
2	12,100	14	22	7	1	0	44
3	16,175	12	56	12	5	12	97
4	16,465	12	22	15	15	7	71
ERROR PROPORTIONS: ALL FIGURES x 10^{-4}							
1		9.594	22.878	2.214	3.690	2.214	40.590
2		11.570	18.182	5.785	0.826	0	36.364
3		7.419	34.621	7.419	3.091	7.419	59.969
4		7.288	13.362	9.110	9.110	4.251	43.122
TOTAL:	58,290	51	131	37	26	22	267
STRATIFIED PROPORTION AVERAGE		8.749	22.474	6.348	4.461	3.774	45.806
NUMBER OF BATCHES WITH ERRORS:							
1		8	15	2	2	3	
2		14	15	7	1	0	
3		11	21	11	5	8	
4		10	15	6	6	5	
ASSUMPTION: BATCH SIZE 110. PROPORTION WITH ERRORS							
1	124	0.0645	0.1210	0.0161	0.0161	0.0242	
2	110	0.1273	0.1364	0.0636	0.0091	0	
3	147	0.0748	0.1429	0.0748	0.0340	0.0544	
4	150	0.0667	0.1000	0.0400	0.0400	0.0333	
TOTALS:	531	43	66	26	14	16	
STRATIFIED PROPORTION AVERAGE		0.0810	0.1243	0.0490	0.0264	0.0301	
HARD-CORE DIFFERENCES (NOT CLEARED AFTER 6 WEEKS)							
1		0	0	0	0	0	
2		0	0	2	0	0	
3		0	4	3	0	0	
4		1	0	0	2	0	

SAMPLES D


20
10
0
MISREAD
MISSING
OVER READ-TWICE OTHER
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13 1
1 2 3 4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
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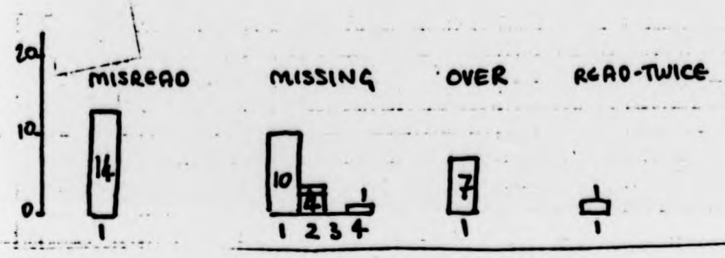
1 2
1 2 3 4
3
1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MISSING
OVER
READ-TWICE
14
10 4 1
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1
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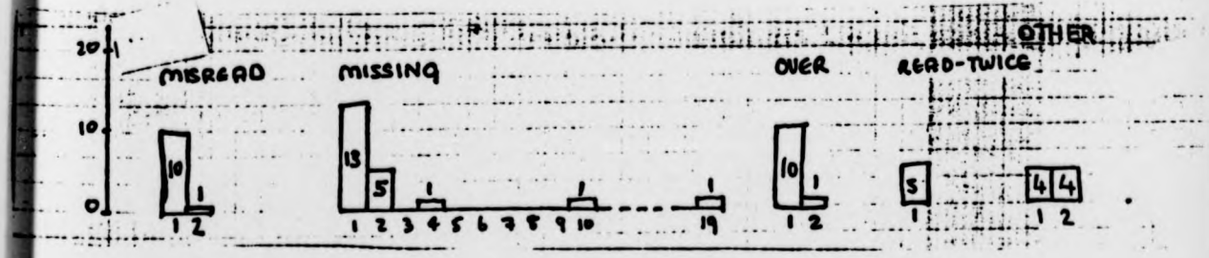
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MISSING
OVER
READ-TWICE
OTHER
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13 5 1 1 1
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5
4 4
1 2
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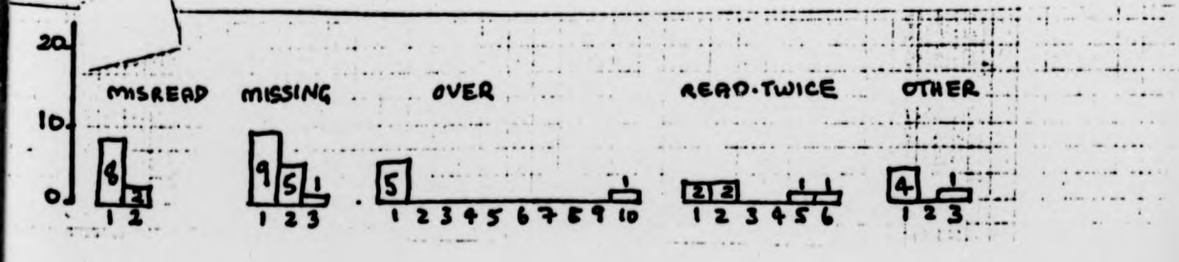
1 2
1
1 2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MISSING
OVER
READ-TWICE
OTHER
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5
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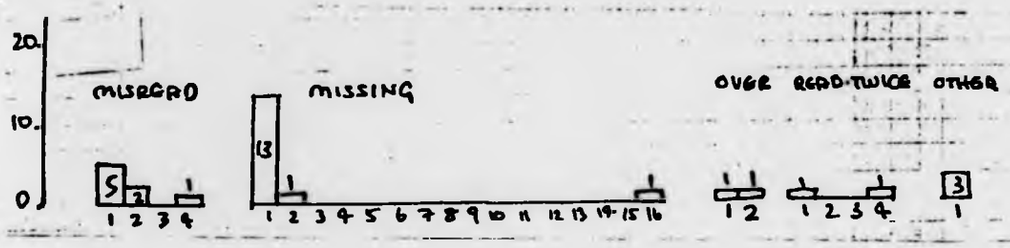
4 1
1 2
1 2 3
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6
1 2 3

SAMPLES D


20.
10.
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER
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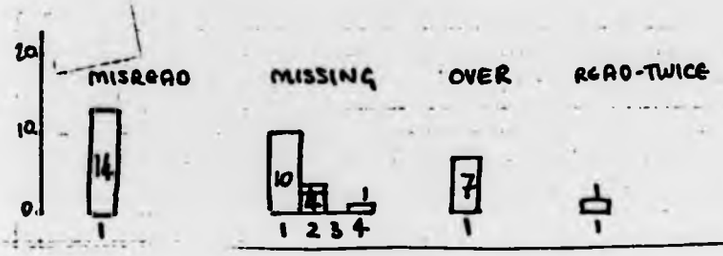
2
1
13
1
3
1 2 3 4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1 2
1 2 3 4
1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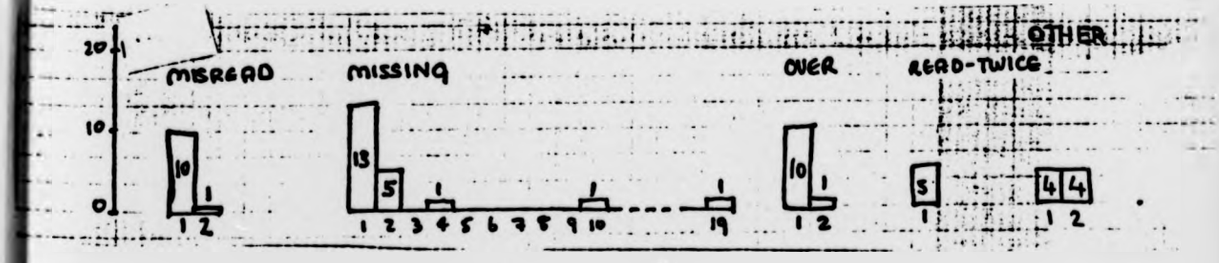
MISREAD
MISSING
OVER
READ-TWICE
14
10
4
1
7
1
1 2 3 4
1
1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MISREAD
MISSING
OVER
READ-TWICE
OTHER
10
1
13
5
1
1
10
1
5
4 4
1 2
1 2 3 4 5 6 7 8 9 10
19
1 2
1
1 2

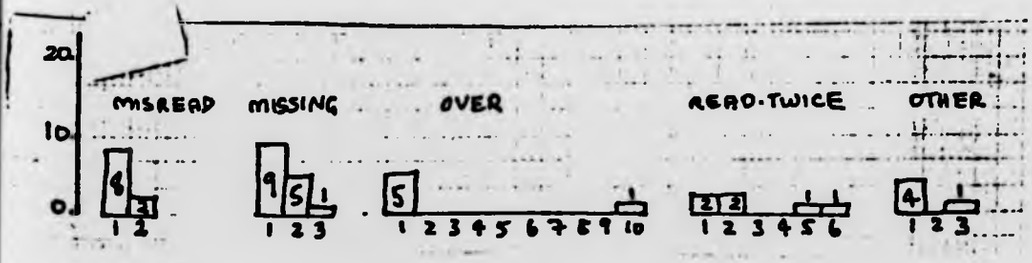
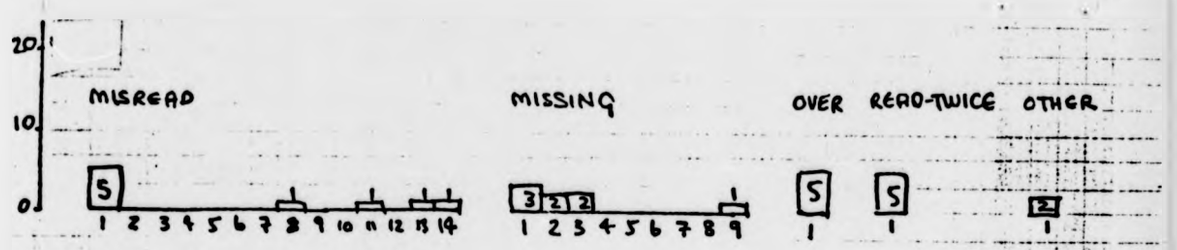

20
10
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER
6
3
9
5
1
5
2 2
1
4
1
1 2
1 2 3
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6
1 2 3

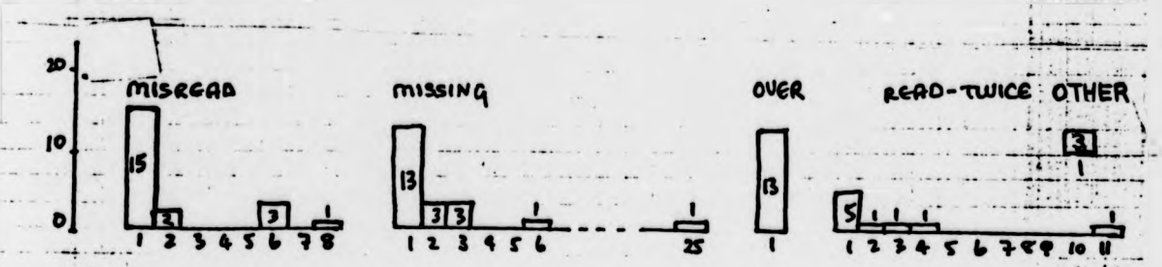
TABLE G.5

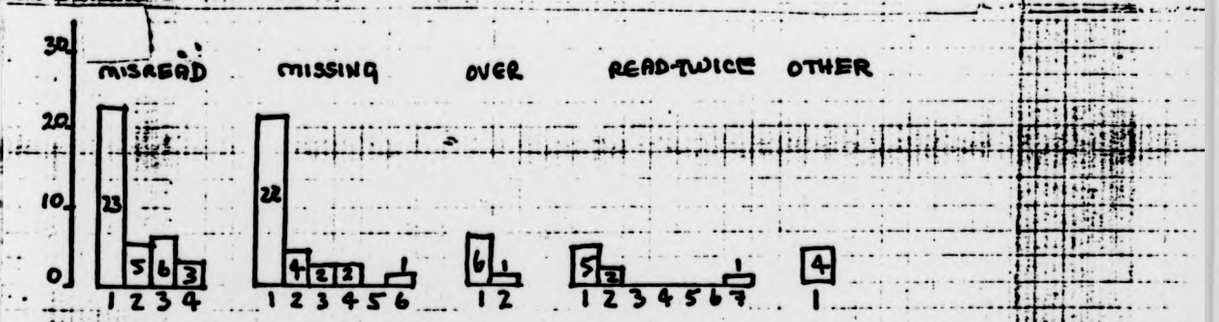
SAMPLES E
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL MISREAD	TOTAL MISSING	TOTAL OVER	TOTAL READ-TWICE	TOTAL OTHER	GRAND TOTAL
1	34,550	62	19	0	12	0	69
2	30,800	51	22	5	5	2	85
3	41,250	45	59	13	25	3	145
4	41,980	63	50	8	16	4	141
	ERROR PROPORTIONS: ALL FIGURES x 10^{-4}						
1		10.999	5.499	0	3.473	0	19.971
2		16.558	7.143	1.623	1.623	0.649	27.597
3		10.907	14.303	3.152	6.061	0.727	35.152
4		15.007	11.910	1.906	3.811	0.953	33.578
TOTAL:	148,580	197	150	26	58	9	440
STRATIFIED PROPORTION AVERAGE		13.259	10.096	1.750	3.904	0.606	29.614
NUMBER OF BATCHES WITH ERRORS:							
1		19	15	0	4	0	
2		9	8	5	5	2	
3		21	21	13	9	3	
4		37	31	7	8	4	
	ASSUMPTION: BATCH SIZE 115.			PROPORTION WITH ERRORS			
1	301	0.0631	0.0498	0	0.0133	0	
2	268	0.0336	0.0299	0.0187	0.0187	0.0075	
3	359	0.0585	0.0585	0.0362	0.0251	0.0084	
4	365	0.1014	0.0849	0.0192	0.0219	0.0110	
TOTALS:	1293	86	75	23	26	9	
STRATIFIED PROPORTION AVERAGE		0.0665	0.0580	0.0178	0.0201	0.0070	
	HARD-CORE DIFFERENCES (NOT CLEARED AFTER 6 WEEKS)						
1		0	0	0	1	0	
2		0	0	0	0	0	
3		1	0	0	2	0	
4		6	6	4	0	0	

SAMPLES E


20
10
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER


20
10
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER


30
20
10
0
MISREAD
MISSING
OVER
READ-TWICE
OTHER

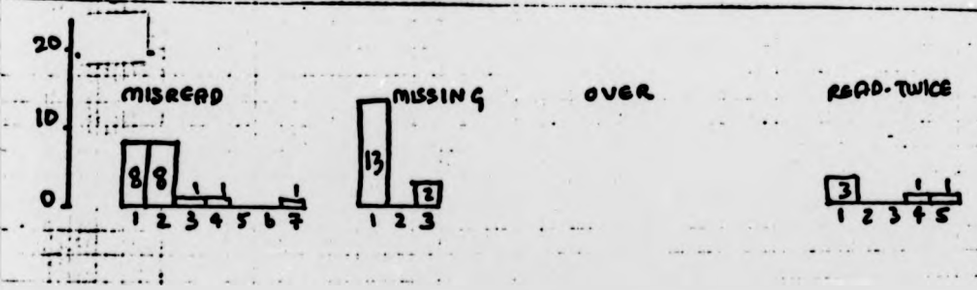
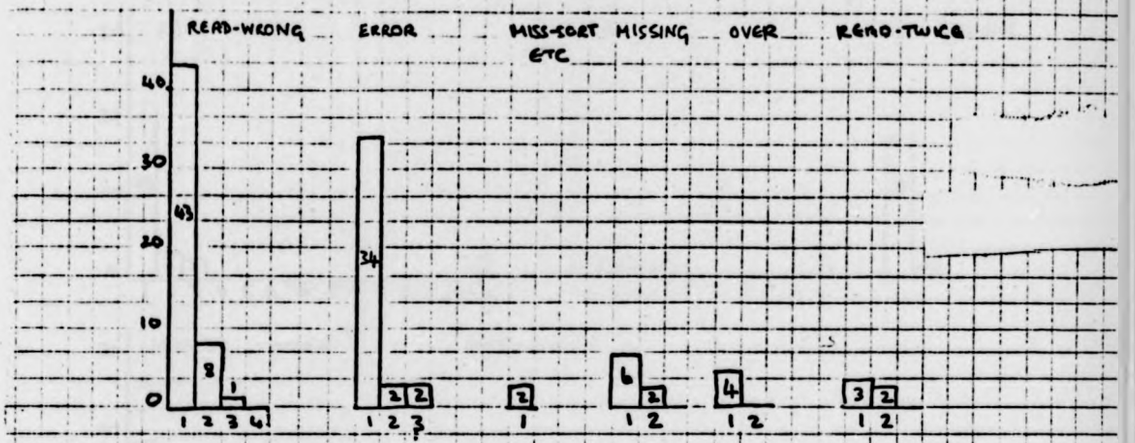

20
10
0
MISREAD
MISSING
OVER
READ-TWICE

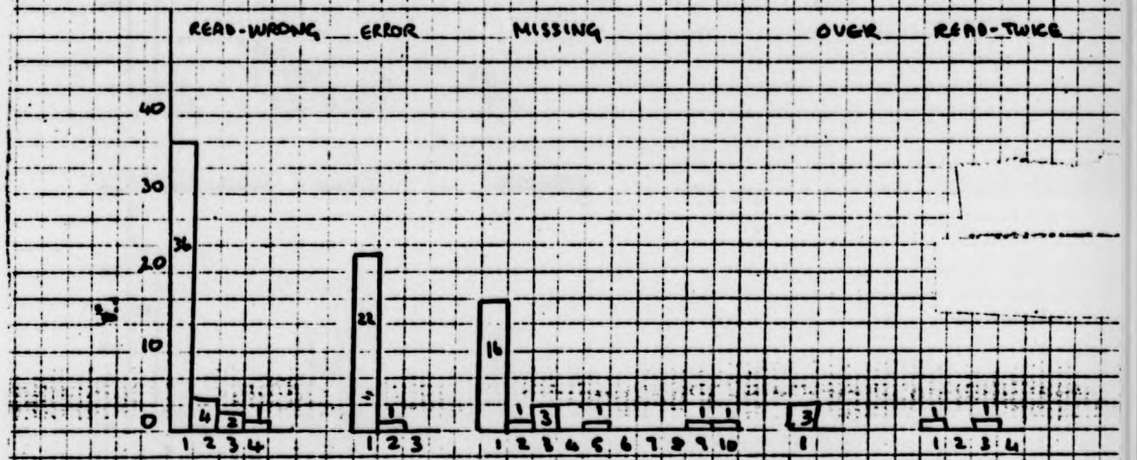
TABLE G.6

SAMPLES F
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL OF READ WRONG	TOTAL OF ERROR	TOTAL OF MIS-SORT ETC.	TOTAL OF MISSING	TOTAL OF OVER	TOTAL OF READ TWICE	GRAND TOTAL
1	263,700	62	44	2	10	4	7	129
2	225,300	54	24	0	51	3	4	136
3	267,700	54	49	2	18	7	9	139
4	170,200	33	23	0	1	0	3	59
5	185,900	51	39	0	7	4	3	104
ERROR PROPORTIONS. ALL FIGURES x 10^{-4}								
1		2.351	1.669	0.076	0.379	0.152	0.266	4.892
2		2.397	1.065	0	2.264	0.133	0.178	6.036
3		2.017	1.830	0.075	0.672	0.262	0.336	5.192
4		1.939	1.351	0	0.059	0	0.118	3.467
5		2.743	2.098	0	0.377	0.215	0.161	5.594
TOTAL:								
	1,112,800	254	179	4	87	18	25	567
STRATIFIED PROPORTION AVERAGE		2.283	1.609	0.036	0.780	0.162	0.225	5.095
NUMBER OF BATCHES WITH ERRORS:								
1		52	38	2	8	4	5	
2		43	23	0	23	3	2	
3		48	44	2	18	5	4	
4		27	23	0	1	0	1	
5		43	34	0	6	3	1	
ASSUMPTION : BATCH SIZE 250 PROPORTION WITH ERRORS								
1	1055	0.0493	0.0360	0.0019	0.0076	0.0038	0.0047	
2	901	0.0477	0.0255	0	0.0255	0.0033	0.0022	
3	1071	0.0448	0.0411	0.0019	0.0168	0.0047	0.0037	
4	681	0.0465	0.0396	0	0.0017	0	0.0017	
5	744	0.0578	0.0457	0	0.0081	0.0040	0.0013	
TOTALS								
	4452	213	162	4	56	15	13	
STRATIFIED PROPORTION AVERAGE:								
	0.0478	0.0364	0.0009	0.0126	0.0034	0.0029		

SAMPLES F


READ-WRONG
ERROR
MISS-SORT MISSING ETC
OVER
READ-TWICE
40
30
20
10
0
43
8
1
34
2
2
2
6
2
4
3
2
1 2 3 4
1 2 3
1
1 2
1 2
1 2


READ-WRONG
ERROR
MISSING
OVER
READ-TWICE
40
30
20
10
0
36
4
3
22
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16
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1
1
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3
1
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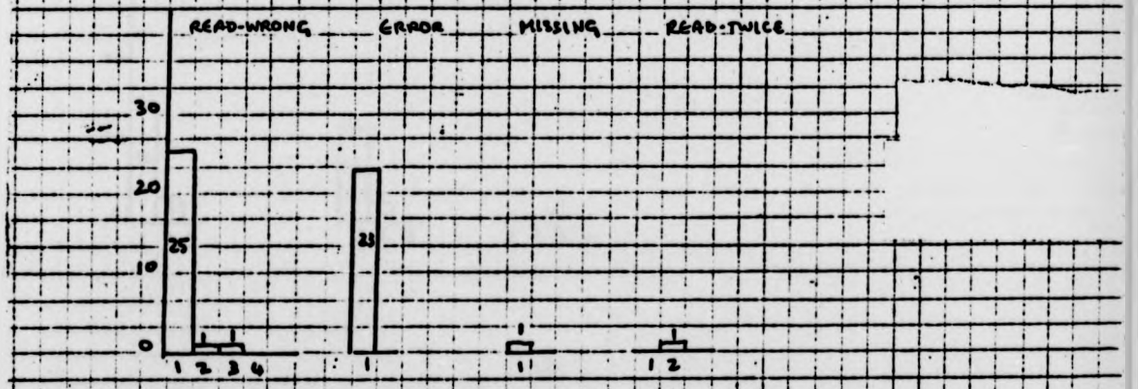
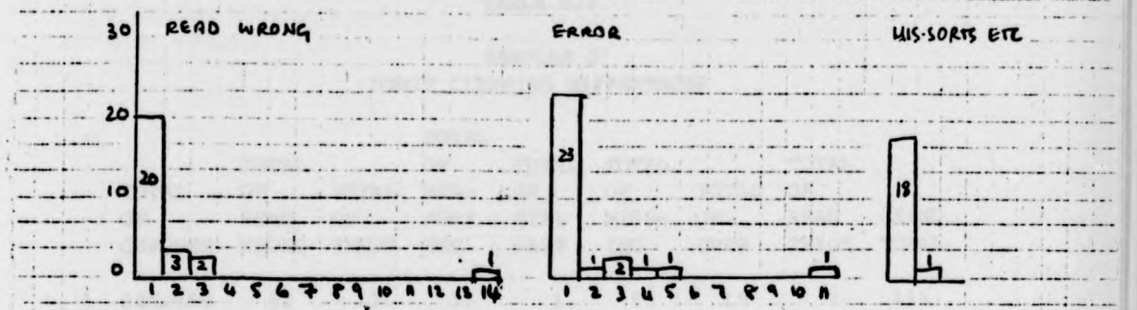
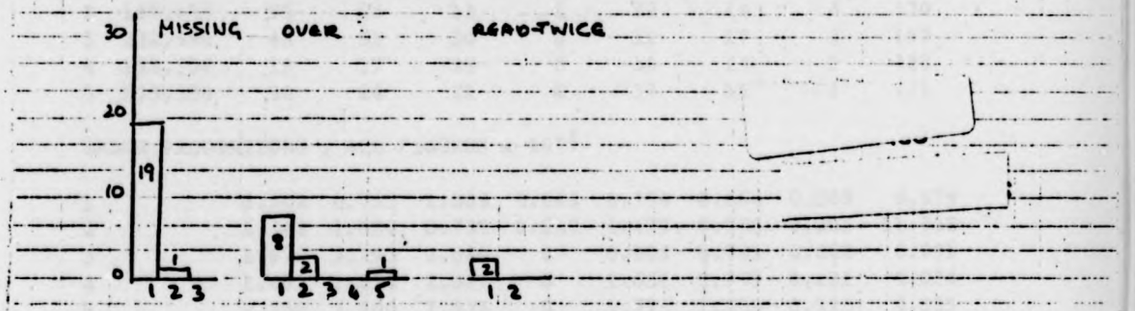
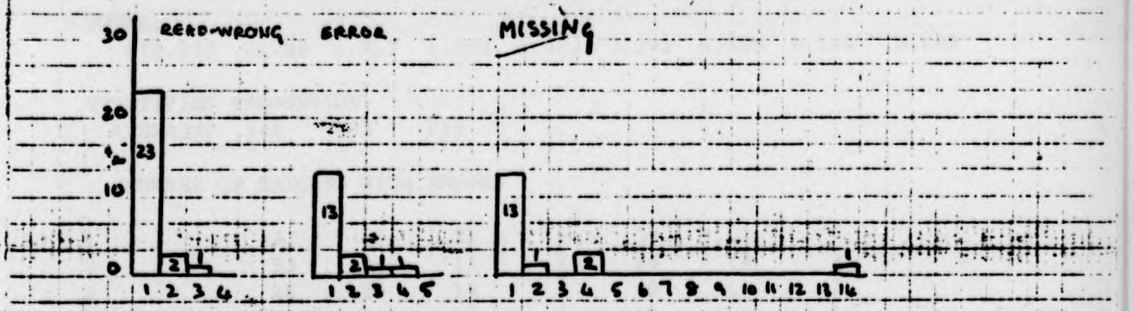
1 2 3
1 2 3 4 5 6 7 8 9 10
1
1 2 3 4


READ-WRONG
ERROR
MISSING
READ-TWICE
30
20
10
0
25
1
1
23
1
1
1
1 2 3 4
1
1
1 2

SAMPLES F


READ WRONG
ERROR
MIS-SORTS ETC


MISSING OVER
READ-TWICE


READ-WRONG
ERROR
MISSING

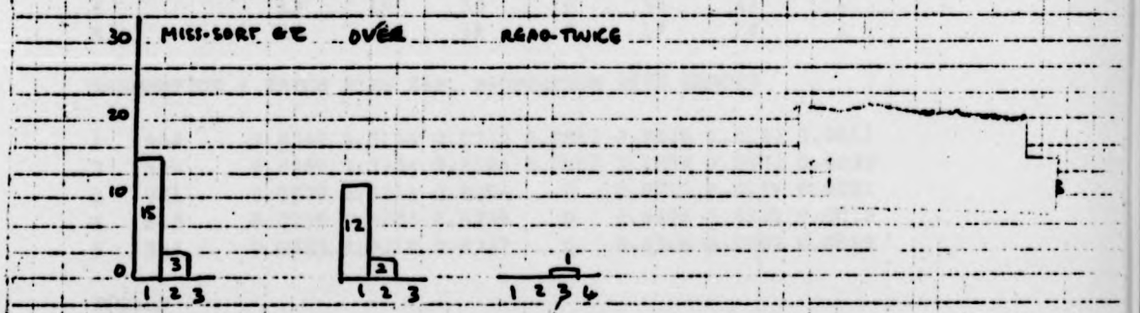
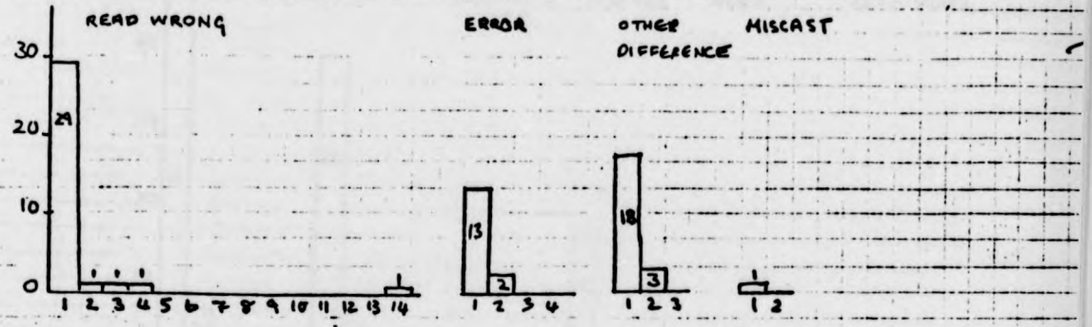

MISS-SORT ETC
OVER
READ-TWICE

TABLE G.7

SAMPLES G
DEBIT CLEARING DIFFERENCES

	TOTAL OF CHEQUES	TOTAL OF READ WRONG	TOTAL OF ERROR	TOTAL OF MIS-SORT ETC.	TOTAL OF MIS-CAST	TOTAL OF MISS-ING	TOTAL OF OVER	TOTAL OF READ TWICE	GRAND TOTAL
1	225,850	52	17	24	1	85	15	2	196
2	149,650	95	24	11	1	22	14	3	170
3	232,550	46	51	20	0	21	17	2	157
4	135,550	19	17	35	0	36	13	3	123
5	133,350	30	24	21	0	37	16	3	131
ERROR PROPORTIONS : ALL FIGURES x 10^{-4}									
1		2.302	0.753	1.063	0.044	3.764	0.664	0.089	8.679
2		6.348	1.604	0.735	0.067	1.470	0.936	0.201	11.336
3		1.978	2.193	0.860	0	0.903	0.731	0.086	6.751
4		1.402	1.254	2.582	0	2.656	0.959	0.221	9.074
5		2.250	1.800	1.575	0	2.775	1.200	0.225	9.825
TOTAL:									
	876,950	2.760	1.517	1.266	0.023	2.292	0.855	0.148	8.860
STRATIFIED PROPORTION AVERAGE:		242	133	111					
NUMBER OF BATCHES WITH ERRORS									
1		33	15	21	1	38	13	1	
2		33	23	11	1	20	14	2	
3		26	29	19	0	20	11	2	
4		13	16	13	0	15	12	1	
5		26	17	18	0	17	14	1	
ASSUMPTION : BATCH SIZE 250, PROPORTION WITH ERRORS									
1	904	0.0365	0.0166	0.0232	0.0011	0.0420	0.0144	0.0011	
2	599	0.0351	0.0384	0.0184	0.0017	0.0334	0.0234	0.0033	
3	931	0.0279	0.0311	0.0204	0	0.0215	0.0118	0.0021	
4	543	0.0239	0.0295	0.0239	0	0.0276	0.0221	0.0018	
5	534	0.0487	0.0318	0.0337	0	0.0318	0.0262	0.0019	
TOTALS									
	3511	131	100	82	2	110	64	7	
STRATIFIED PROPORTION AVERAGE									
	0.0373	0.0285	0.0234	0.0006	0.0313	0.0182	0.0020		

SAMPLES 9


READ WRONG
ERROR
OTHER DIFFERENCE
MISCAST
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20
10
0
29
13
18
3
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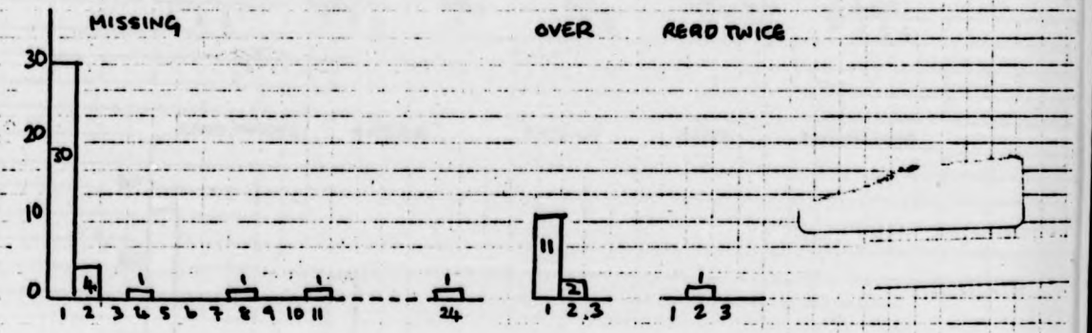
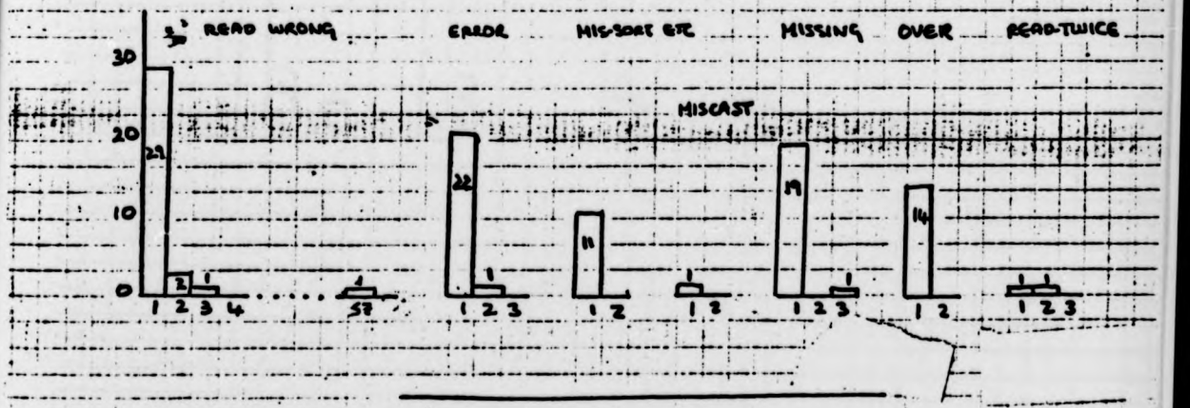
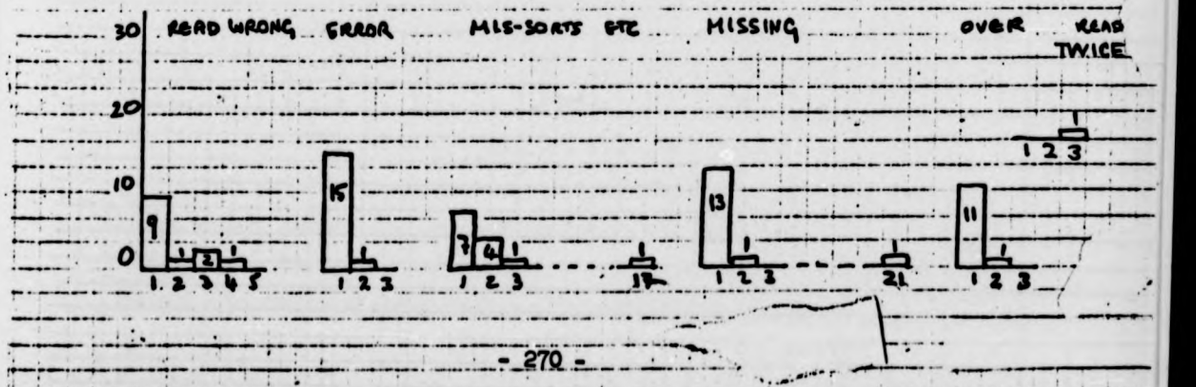
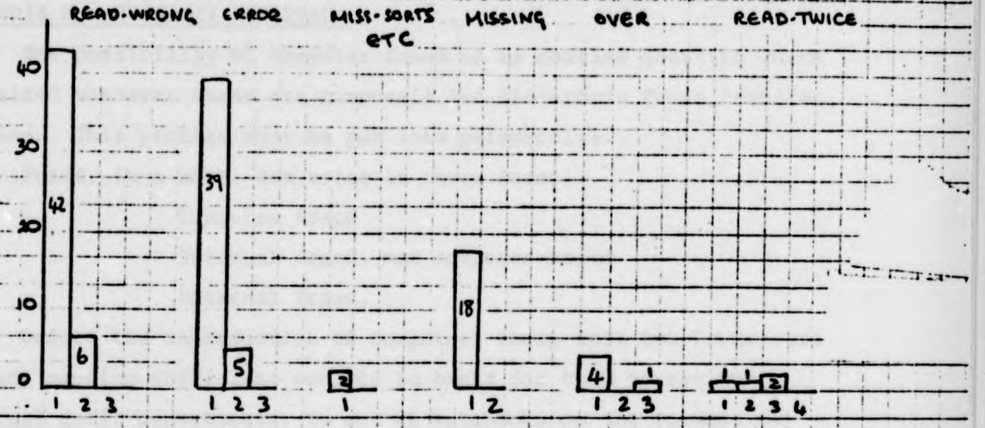
1 2 3 4
1 2 3
1 2


MISSING
OVER
READ TWICE
30
20
10
0
30
4
11
2
1 2 3 4 5 6 7 8 9 10 11
24
1 2 3
1 2 3


READ WRONG
ERROR
MIS-SORT ETC
MISSING
OVER
READ-TWICE
MISCAST
30
20
10
0
29
3
22
11
19
14
1 2 3 4
58
1 2 3
1 2
1 2
1 2 3
1 2
1 2 3


READ WRONG
ERROR
MIS-SORTS ETC
MISSING
OVER
READ TWICE
30
20
10
0
9
15
7
4
13
11
1 2 3 4 5
1 2 3
1 2 3
18
1 2 3
21
1 2 3
1 2 3

SAMPLES G


READ-WRONG
ERROR
MISS-SORTS ETC
MISSING
OVER
READ-TWICE
40
30
20
10
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42
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39
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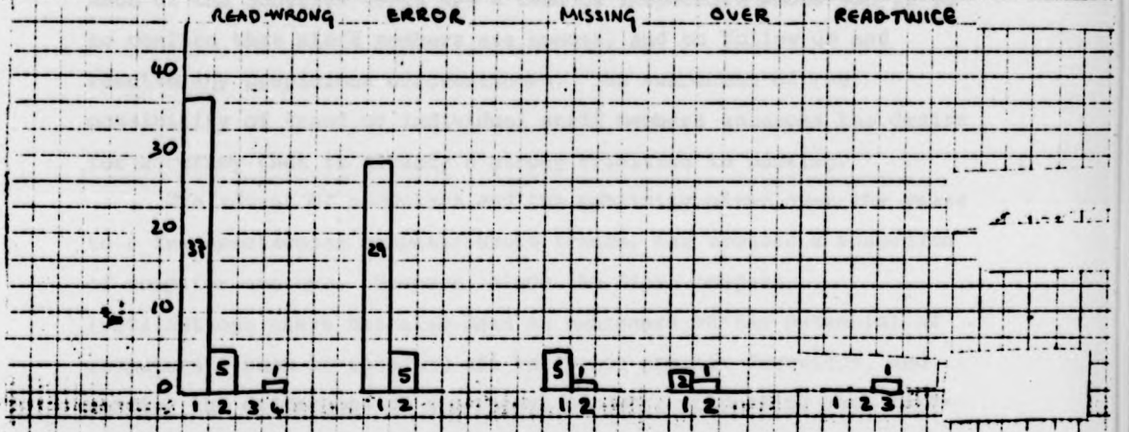
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ERROR
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APPENDIX H : SECURITY AND FRAUD

The possibility of computer fraud is an emotive question which is raised whenever there are proposals for Electronic Funds transfer Systems. This problem must be put into perspective.

Fraud, in a bank, can arise in three forms:-

Computer fraud

Internal fraud, not computer-based

External fraud.

Before the introduction of computers these last two forms were already causing sufficient concern to banks for them to set up internal audit departments, to act as watchdogs on the conduct of staff, and to assist police in the detection of external fraud. Each of the Scottish Banks has a team of inspectors whose job it is to confirm that staff members are honest, and to follow up and resolve any suspicious circumstances. The awareness of the possibility of fraud by individual staff members enhances the desire for accuracy that is already a strong tradition in banking.

The advent of computers and the publicity given over the years to a few spectacular computer-based frauds, has aroused a suspicion of computer systems. However, since the first computer installations there has also been an awareness of the potential of computers - such as rounding all halfpence amounts downwards, and sending the difference to a personal account, or putting very large amounts on very short term deposit and amassing the interest. Because of the awareness of a potential for large fraud, as opposed to the fairly petty fraud that might be practiced by telling and other staff, all Banks have evolved an elaborate process of checking system implementations, and system changes. In addition, access to files is invariably through a hierarchy of pass-words, so that no working programs can be changed without due authority.

Banks do not, as a matter of policy, publish details of fraud. However, in terms of the value of losses to banks in Britain, indications are that the three forms above are listed in increasing order of magnitude, with the total losses per annum in external fraud greatly exceeding the losses from internal fraud. The chief losses are, apparently, from the use of stolen cheque books and credit cards. There is no indication that there has ever been any computer-based fraud within the Scottish Banks.

The security precautions against computer fraud in internal bank systems are such as to make it extremely difficult for any to occur. Where computer systems are subscribed to by a number of banks - such as BACS, SWIFT, ACCESS and BARCLAYCARD - similar security arrangements are built in, and adhered to by subscribers.

GLOSSARY

AUTOMATION	-	The replacement of human effort by computer-controlled machinery.
CASH-ISSUING TERMINAL	-	An on-line terminal allowing customers to withdraw money from a bank, usually operated by a magnetic stripe card.
C.O.M.	-	A microfiche which contains computer output that can be read using a magnifying viewer.
COMPLETE INFORMATION SYSTEM	-	See Chapter 3.1. An information system which has a complete record of all data input.
COMPUTER-BASED INFORMATION SYSTEM	-	See Chapter 3.1. An information system in which the computer provides for all the flow, storage and processing of data and for information output.
DATA	-	See Chapter 3.1. A collection of facts and figures and relations between facts and figures in any order.
DATA PROCESSING	-	Manipulation of data by a computer.
D.C.V.	-	A voucher which is used in automated clearing systems to give instructions about batches or batch destination to the computer.
DIRECT-DEBIT	-	See Chapter 5.4. The deduction of regular payments from a debtor account by the creditor.
EFFICIENT RETRIEVAL SYSTEM	-	See Chapter 3.1. A retrieval system in which there is a one-one relation between retrieval codes and data to be retrieved.

GLOSSARY (cont'd)

INFORMATION	-	Organised meaningful data.
INFORMATION SYSTEM	-	See Chapter 3.1. A system which processes data into information.
MAGNETIC STRIPE CARD	-	A card with a stripe of encodable material which can then be read by machine.
MICR	-	A font of characters in magnetic ink which can be read by machine.
O.C.R.	-	A font of characters which can be read optically by machine.
POINT-OF-SALE	-	A system of initiating direct-debits from customer accounts at retail outlets.
READILY AVAILABLE INFORMATION SYSTEM	-	See Chapter 3.1. An information system which produces information in a timely and cost-effective manner.
RETAIL BANKING	-	See Chapter 2.3. Collection of small deposits from customers and making of (relatively speaking) small advances, plus allied services.
STATIC	-	See Chapter 5.1.1. The permanent details concerning an account.
TELLER TERMINAL	-	A computer terminal operated by a teller at a bank counter.
TRANSACTION	-	See Chapter 5.1.2. An activity which generates credits and debits. Each credit or debit constitutes a movement in some account.

Principal Notation

D - Deposits

A - Advances

p - proportion of deposits - interest bearing

C - total of current account and service charges p.a.

s - effective rate earned on advances p.a.

r - effective rate paid on deposits p.a.

k - proportion of deposits that become advances

E - total expenses p.a.

N = $-\frac{(C-E)}{D}$ = net relative cost of deposits

m = s - r = effective margin p.a.

I = amount of regular input to an account

X = number of thousand members of staff

v - number of inputs to an account each year

w - number of withdrawals

e - cost of an input in a deposit account

f - cost of a deposit account withdrawal

g - net cost of a cheque withdrawal (actual cost less charge collected)

h - cost of keeping an account on record per annum.

d - staff growth p.a. without computerisation

j - net return required on capital p.a.

q - annual increase in salaries and expenses

L - time horizon for calculating net present value

B - daily positive or negative clearing balancing figure

Q - present value of clearing balancing sums

i = effective return on funds per annum

v_d = effective daily discount rate on funds

K - annual volume of clearings

In minor modelling some of the above have been used with different meanings.