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I. Introduction

The commercial banking industry is likely to face sizable challenges in the mid-1980's. Deregulation legislation, such as the Depository Institution Deregulation and Monetary Control Act of 1980 and the Garn-St. Germain Depository Institutional Act of 1982, has freed commercial banks to compete more intensely with other banks and with other financial service institutions. Examination of other industries which have gone or are going through the deregulation process, such as the brokerage, trucking, and airline industries provide little solace for bank managers. Large numbers of less efficient firms in those industries have been forced to fail or combine with other firms. In the airline industry, competition has become so intense that the majority of the companies have losses rather than profits. The fact that many of these changes are occurring in a difficult economic period — slow growth, high real interest rates, and fluctuating nominal interest rates — makes the task that much more difficult.

More specifically the challenge to many banks may be a declining net interest margin. Rates earned by banks will be more competitive under deregulation. Rates paid by banks will rise (relative to rates earned) because of the near elimination of Regulation Q and the popularity of the new nationwide super NOW accounts and insured money market deposit accounts. This declining net interest margin will probably be more harmful to medium and small sized banks whose deposits usually included large amounts of demand and passbook deposits than larger banks which purchased most of their funds. The concern,

particularly for small and medium sized banks, becomes can we achieve enough economies in other areas to overcome the pressures of deregulation on net interest margin?

There are several possible areas of bank management which are likely candidates for achieving such economies. One relatively new possibility is through effective use of microcomputers. Interest in these microcomputers within the banking community is growing by leaps and bounds -- and for good reasons. Microcomputers, which cost between $5,000 and $10,000 with selected useful software, have as much storage capacity and memory as computers which sold for several million dollars in the 1960's. Even more important, "user-friendly" software so that practically anyone can perform a multitude of banking tasks is increasingly available.

The purpose of this paper is to examine the potential areas in which banks of all sizes may find microcomputers a major force in achieving the needed efficiencies. We analyze the information requirements in these areas and suggest applications which can improve managerial decisions and operating efficiency.

II. Information Requirements and Potentials of Microcomputers

The microcomputer has potential usage in nearly all aspects of commercial banking. Advantages of the microcomputer include a low price tag, ease of use, the availability of user-friendly, menu-driven, and error trapping softwares and the capability of expansion and interface with other information storage and processing units. For expositional convenience, we will divide our analysis of the potential uses of and the information requirements for the microcomputer into six interrelated areas in commercial bank management: (A) strategic management, (B) specific functional management including loan

portfolio management, investment portfolio management, and management of deposit accounts, (C) bank operations, (D) bank consulting services, (E) bank marketing, and (F) bank communication including both external and internal communication.

A. Strategic Management

Strategic management of a bank concerns the optimal allocation of the bank's resources in a changing environment to achieve certain economic goals of the bank. As such, this aspect of bank management deals with the management of the financial statements of the bank and is usually referred to as asset and liability management or balance sheet management. Information required for strategic management includes the broad categorization of asset and liability accounts and their characteristics such as maturity, rates and amount, and selected information and a set of assumptions. Management seeks to answer questions such as: How much to pay to aquire funds, when and from what source? How to allocate funds? When, and for what use?

Two approaches have been used in strategic management: (1) financial statement projection type of models and (2) optimization models. We will briefly discuss these two approaches and their suitability and applicability using microcomputers below.

1. Financial Statement Projection Models

Based on assumptions about the bank's accounts and the economic environment projected for the future, these models generate pro forma financial statements including balance sheets, income statements, sources and uses of funds and various performance measures. The set of assumptions usually includes the growth rates of various accounts on the balance sheet and interest

rate projections. By experimenting with the different growth and interest rate scenarios, this type of model allows the user to answer "what if" questions and facilitates the evaluation of the potential impact of selected decisions and environment on the bank. Because the approach taken is in tune with the planning process currently used by many bankers, it is fairly extensively used by banks, especially the larger banks. Currently, the majority of these types of models reside in main frame computers or minicomputers either in-house or available through a vendor network (See Robinson [1973], Derwa [1972], and Royer [1975]).

While the approach is relatively simple, the programming tasks involved require substantial resources and specialized personnel which are most likely to be in short supply at smaller banks. With the advent of microcomputers, we believe that this requirement is no longer a major obstacle.[1] Easy to use and relatively low priced software such as VISICALC and 1, 2, 3 allows users to formulate and "program" the model for use within a very short time period. For example, VISICALC is one version of an electronic spread sheet program which allows users to specify values (e.g., for a balance sheet or income statements) and relationships on a big spread sheet as part of a cell of a matrix. These softwares (electronic spread sheets) are designed to facilitate easy data entry and report generation. The process of building a model is very much similar to analysis by hand calculation done in pro forma balance sheet generation. The softwares merely speed up the process. Since the softwares are usable by many microcomputer owners, the developmental costs can be shared and the retail cost is very low.

Using the electronic spread sheet softwares, various forms of models can be programmed to fill the needs of individual banks. Strategic planning models can be used to examine interest risk exposure, to analyze the potential

impact of gapping and reverse gapping, to control liquidity position, and even to analyze and use more recent development in hedging strategy (e.g., see McCabe and Blackwell [1981]; Grant and Hempel [1982]), and to examine the effect of changes in regulation. Some of the applications in this area of banking are already available, others are being developed by independent software vendors, and still others will be forthcoming as markets for them develop. Our contention is that even without the packaged models, bankers with a little training can easily program models to suit their own needs. For example, some banking schools, including the Southwestern Graduate School of Banking at Southern Methodist University and the Stonier Graduate School of Banking at Rutgers, are incorporating modules or electives in microcomputers into the curriculum to facilitate this process. While microcomputers can benefit all banks in this aspect of management, we believe that the smaller banks will benefit more because with microcomputers, strategic management is feasible for the first time.

2. Optimization Models

In addition to the requirement for specifying the values and characteristics of various accounts of the balance sheets and income statements, optimization models also require explicit specifications of various relationships both within a time period and between time periods. These constraints include (1) accounting constraints which tabulate the relationships of the various accounts; (2) market constraints which provide information on the potential demand and supply conditions of loans, deposits, etc.; (3) regulatory constraints which depict regulations imposed by various regulatory authorities such as liquidity and capital adequacy requirements; and (4) management policy constraints which reflect management's experience or mandate. Based on a set of economic scenarios about future interest rates and market potentials, and a

pre-specified objective of the bank, the models seek to determine the optimal set of strategy to be implemented and indicate the future effect by generating pro forma financial statements. While optimization models are often more difficult for bank management to formulate and understand than projection models, these types of strategic planning models have distinct advantage over the projection type of models. The mathematical programming models can determine the optimal set of values in the bank's asset, liability and capital accounts given a set of constraints while the projection type can evaluate a limited set of alternatives. Various forms of this type of mathematical programming models have been formulated and quite a few have been used by larger banks[2] (e.g., see Cohen and Hammer [1967] [1972], Cohen and Lam [1979], Komar [1971], Fielitz and Loeffler [1979], Fortson and Dince [1977]).

The optimization approach to strategic planning is not as widely used as the financial statement projection approach for various reasons. First the approach requires personnel who have some understanding of mathematical programming techniques and can communicate well with senior management. Second, it is necessary for senior management to explicitly specify the objective(s) of the bank for the model to function. While this aspect in the implementation of a successful model is very beneficial, it does take time and commitment from top management of the bank.

It is technically feasible to incorporate such planning tools in microcomputers with larger data storage capacity and faster computation capability; however, the human obstacles discussed above still remain. One positive note is that more bankers now have the formal training and exposure to these techniques and when a properly designed software package is available with interactive capability, this approach can be immensely helpful especially in conjunction with the financial statement capability.

B. Specific Functional Management

In addition to potential use in strategic planning, microcomputers can also be cost effective in various functional management areas. Microcomputers may be effective in responsive information storage, retrieval, processing, and decision making. The following discuss the applicability and information requirements in (1) loan portfolio management, (2) investment portfolio management and (3) deposit accounts management.

1. Loan Portfolio Management

Loan management deals with a large volume of information specifically related to individual customers. The majority of the information processing may not be for accounting purposes such as billing. Microcomputers are useful in all areas including credit evaluation, loan pricing, customer profitability analysis, collection and charge off.

Starting with credit evaluation, spread sheet analysis of commercial customers can be readily performed by programs using software such as the VISICALC or 1, 2, 3 electronic spread sheets discussed previously. Pro forma financial statements based on both the applicant's and the loan officer's assumptions can be compared and evaluated efficiently. Various performance measures such as profitability ratios, liquidity ratios, and operating efficiency ratios can be easily compared with industrial norms from Robert Morris Associates (RMA). Cash flow projections, funds flow projection, and working capital analysis can also be incorporated. If these tedious calculations can be automated, the time of a bank loan officer can be directed more to other essential areas of evaluation such as managerial style and competitive environment. Thus, the microcomputer can reduce the decision time and be more responsive to the customer's need.

Similar comments can be applied to consumer credit analysis. Given an applicant's current financial position and future earnings potential, software

can be constructed to evaluate the repayment capability of an individual customer. In certain cases where the customer's own proposal may not satisfy the bank's credit criteria, the loan officer can suggest alternatives, including amortization schedules, which best fit the customer's need in a relatively short period of time. Obviously, this responsiveness improves long-term relationships. In certain banks where credit scoring models (see, e.g., Altman et al., [1977], Orgler [1970], [1971]), are desired, such a credit scoring system can easily reside in a storage medium for easy access.

Once a customer is decided to be credit worthy, loan pricing can also be done on the microcomputer. Whatever the pricing scheme is, be it based on return on purchased funds, return on asset, or return on capital, software can be easily developed for this purpose. We contend that as long as the bank has decided on a pricing mechanism, pricing of loans including the pricing of balance deficiency fees (see Lam and Boudreaux [1983]) can be feasible using microcomputers as a decision aid.

One aspect of loan pricing in addition to risk analysis is the determination of the cost of funds to support the loan. The cost of fund analysis involves an evaluation of the weighted average of the marginal costs of the bank's various sources of funding (e.g., see Watson [1978]). The individual component cost and its weightage can be obtained via interface with other files. Initially, before the loan pricing system has this capability, the required information may be input directly by the loan department.

Customer profitability analysis is commonly done to evaluate and monitor the profitability of bank customer relationships, usually after a loan is granted (e.g., see Knight [1975]). While the information requirement includes other activities of the loan customer such as deposit balances and consulting activities, the analysis program is not difficult. For smaller banks with

fewer customer base, information on other activities can be extracted from other files. For larger banks with mainframe computers, interfacing the microcomputer with the mainframe may be a solution.

Since customer profitability analysis involves evaluation of all bank-customer relationships which transcend different functional management areas, utilizing microcomputers in this analysis requires careful planning especially in software design and data base management. Software for other functional management must also be flexible to interact with other functional areas software.

Microcomputers can also be a valuable tool when a loan is in default especially when the loan officer has direct access and usage of the microcomputer. Depending on the loan policy of the bank, billings and letters can be sent out after a specified period of time. The micros can be used to keep track of collection efforts and monitor the progress in making payment. In certain cases, software can be written to restructure loan repayment schedule when financial and economic circumstances dictate it. The loan department may even decide to utilize models to determine the optimal collection policy (Bierman and Hausman [1970], Dirickx and Wakeman [1976], Mehta [1970]).

Other potential areas of application include credit training and performance evaluation of the loan portfolio by officer, type, geographical location and by branch. Actual loan cases (loan application, pricing and profitability analysis) can be stored in storage media and credit analysts in training can be asked to analyze and make recommendations. Having electronic spread sheets software available, the analysis time can be reduced substantially. Of course, this approach should be taken only after the credit trainee has sufficient understanding of the credit evaluation process. With this tool, the loan officers and managers in charge can devote more time to instill their own

experience into the training process and to emphasize the not so obvious areas of concern.

If the data base structure is properly designed, evaluation of loan portfolio performance by originating loan officers, loan type or branch merely involve proper sorting and tabulation. The performance measures can include loan volume, loan profit, default amount and percentage. Such information should be a valuable management tool.

In sum, we believe that the microcomputer will have great potential in loan portfolio management. Given proper design, and education, it can greatly assist loan management. The extent of utilization in a particular bank will depend on the current data processing arrangement that the loan department has, the current loan evaluation procedure and policy. At the very least, we believe that the micro can be useful in spread sheet analysis, amortization schedule and credit training even in small banks.

2. Investment Portfolio Management[3]

Banks invest their excess funds mainly in U.S. Government securities, agency securities, state and local government securities of various maturities. The management in this area involves determining the optimal maturity structure, the purchase and sale of securities to maximize return on investment and at the same time satisfy various liquidity, capital adequacy and pledging requirements imposed by regulators, by management mandate or by creditors.

Mathematical programming models (optimization) have been formulated to help determine the "optimal" investment strategy given a set of assumptions of future events and a specified objective (e.g., see Hodges and Schaefer [1977], Bradley and Crane [1973], Bradley and Crane [1975], and Lane [1974]). The approach taken is similar to the optimization approach discussed in the

strategic management section. While some of the models have been successfully implemented in various banks,[4] our speculation is that this approach will not be applied using the microcumputer in the near future. The key obstacle is the training and understanding of the techniques involved which usually requires specialized personnel. However, when some well designed interactive softwares are available for use by bankers, the remaining obstacle is more psychological than anything else. Bankers are finding that they need not have an intimate knowledge of the internal operation and technology of the computer nor the technical computational procedures used in a model to find the tools useful.

Probably the most useful model implementable in a microcomputer for bond portfolio management involves some form of computer simulation. Such an approach has been developed by Gifford Fong Associates as reported by Marcial [1979] in the Wall Street Journal and used by many large banks. The model requests information on current bond portfolio holdings and future yield curve forecast. The model then provides analysis of impact of the forecast yield curve on risk and return of the securities in the portfolio. The investment officers can experiment with various yield projections and decide on the optimal buy, sell and hold strategy given his bank's particular need. Using such an analysis, he can also evaluate a particular bond swap strategy. Given the volatility of yield in recent years, this decision tool would be immensely helpful. Because the approach is attuned to decision making process of investment managers we would expect that the softwares in this area will be more widely utilized when they are adapted to the microcomputers.

Other potential areas of specific application in investment management include evaluation of swap and arbitrage opportunities, analysis of term structure of interest rates, tabulation and evaluation of repurchase agreements, investment risk analysis and hedging. We feel that application in

arbitrage opportunities (see, e.g., Kramer [1970]) would be limited to larger banks or security dealers. Software to analyze term structure of interest rates (e.g., see McDavid and Bettes [1978]) would be very useful, especially in conjunction with the simulation model discussed. Computer programs to tabulate and evaluate securities used in repurchase agreements should be helpful to small and larger banks alike. While recent development in hedging and immunization strategy using financial futures and the duration concepts (see, e.g., Fisher and Weil [1971], Bierman [1977], Bierwag, Kaufmann and Alden [1983] and Grant and Hempel [1982]) have great potential, the extent of utilization using the microcomputer depends on the sophistication of the users. Most likely, such applications will not be as extensive in the smaller banks in the near future.

3. Deposit Accounts Management

As the industry continues to deregulate, more and more new products such as the Money Market Accounts (MMA), Individual Retirement Accounts (IRA), the NOW accounts, the Super-NOW Accounts and the Small Saver Accounts will proliferate. With increasing competition for funds among banks and between financial institutions and non-financial institutions, the viability and success of a bank depend on the intimate knowledge of the costs and characteristics of the funding sources. Microcomputers are especially helpful in providing such information in an efficient and cost effective manner.

Consider for example, the recent introduction of the MMA account which has no interest rate ceiling. Microcomputers can be used to analyze the proper pricing of the product. Analysis can also be done to evaluate the impact of this new product on the costs of funding as invariably certain proportion of other low yield accounts will be transferred to this new product. "What if" questions can be answered readily before the product is introduced.

Similarly pricing of other deposit products such as the demand deposit accounts, IRA accounts, can be analyzed and updated by utilizing the microcomputer to insure profitability. Where applicable, alternative pricing schemes can be introduced to achieve the same yield to suit customers with different usage patterns.

Statistical analysis programs can also be used to analyze deposits demand and withdrawal patterns. Such analysis can usually identify seasonal and cyclical patterns based on past history.

Moreover, information on requirements, fees, rates, etc. on all products can be stored in the microcomputer to facilitate questions by potential customers (see Long [1982]). With the help of the information, new account representatives can answer questions involving the likely distribution pattern of an IRA and help prospective depositors in their decisions. Such a responsive and personal approach would definitely enhance customer-bank relationship and is cost effective, even for small banks.

C. Bank Operations

Bank operations include check processing and manpower planning. In recent years, increasing level of interest cost (in terms of float) and labor cost have focused management's attention in the efficiency of bank operations. In the area of check processing, models have been developed and implemented to reduce time to pick up checks from branches (see, e.g., Svestka [1976], Haas and Zoltners [1977]) to sort checks into groups (see, e.g., Murphy and Stohr [1977], and to speed up the collection of funds from the drawee banks (see, e.g., Hess [1975]). Such models, if available in microcomputer software, would be tremendously helpful to medium and large size banks. Depending on the changing pattern of check characteristics (volume of checks, size of checks and the drawee locations), the model can be updated periodically to

improve operating efficiency. In the past, smaller banks usually did not have enough resources to benefit from such an approach. With user friendly softwares in the micros at a low price, smaller banks may also stand to benefit from these management techniques.

Manpower planning is another potential area of application (e.g., see Jones, Morrison and Whitman [1973], Morndra [1976]). Using statistical techniques such as queuing theory, pattern of banking, service demand (including lines in the bank lobby and drive-in facilities) during each day of the week can be analyzed and most cost effective scheduling of employees can be determined to give the best service. Such optimal scheduling scheme reduces operating costs and increases service. In certain cases, it may even help to reduce capital outlay in new equipment. We believe that the application of microcomputer in this area would be most beneficial to medium and large banks.

D. Bank Consulting Services

As the industry continues to be deregulated, products and services will be more unbundled and fees generated from consulting services should be an increasing proportion of the bank's revenue. Microcomputers can play an important role in this area. The potential areas of application include: cash management, short-term financial planning, trust services and other miscellaneous services.

Corporations are increasingly aware of the cost of idle funds and would pay for ways to speed up the collection of funds and delay payments. Models to speed up the collection effort have been used by large banks as part of their consulting services and are commonly known as lock box program (see, e.g., Maier and Vander Weide [1974]). The converse problem of delaying payment, the disbursement program has also been formulated and used (see Shanker and Zoltners [1972]). In fact, the larger problem in designing the complete

multi-bank relationship has also been formulated and used (see, e.g., Calman [1968], Maier and Vander Weide [1976]). While such a comprehensive system may be potentially implemented using a microcomputer, the cost benefit analysis would most likely preclude participation by smaller banks.

Short-term financial planning involves the management of short term financial assets and liabilities. For example, given a projected cash-flow pattern of a firm in the future (some may be cash inflow, some may be cash outflow), the bank can advise the firm in the optimal investment and borrowing strategy. With the aid of a microcomputer, fees from this service can be an added revenue for both small and large banks. Similarly, personalized services for individuals can also be provided.

Trust service has historically been unprofitable for smaller accounts for various reasons. In particular, the design of a program involves not only financial expertise but also knowledge of legal constraints and tax consequences. A well designed microcomputer program with proper legal and tax information can be used to service smaller accounts profitably. In addition to the fee revenue, the bank can also benefit from other bank customers relationship.

Depending on the clientele of a bank, bankers can utilize their specialized knowledge of a particular field in conjunction with the microcomputer to help financial decision making of the bank's customers. For example, in banks dealing with farmers, bankers can help farmers in their lease or buy decisions. Or the banker can help the farmers in deciding whether to sell their excess crops or store them for later sale.

E. Bank Marketing

As the banking industry continues to be deregulated, and competition becomes increasingly keen, marketing strategies of banks will have to be more

sophisticated and cost effective. Banks must provide individualized services to attract or retain the increasingly sophisticated customers at a low cost so as to distinguish themselves from financial products of other institutions. Microcomputer technology can be such a vehicle.

Take the recently introduced IRA for example. Potential customers usually would like to know the future impact at retirement of their saving pattern before signing up for such an account. Or, some may want to know if it is advisable to borrow to fund their IRA account. With the aid of a microcomputer, individualized analysis can be provided at a relatively low cost. And with proper training, a receptionist can easily handle such inquiry and analysis. An individualized report can even be provided. This personalized and responsive approach should be an effective marketing scheme.

It is not difficult to expand the above strategy to cover other products including other deposit accounts and loan services. In fact, the microcomputer technology can be expanded to provide similar marketing aid without the presence of a bank employee. Microcomputers can be made available at the bank's lobby for direct inquiry by customers.[5] In banks catering to special groups of customers, such as farmers, or retirees, special softwares can be developed to answer inquiries of the particular group. Our contention is that such a responsive approach will not only help to retain current customers, but also attract other customers with similar needs.

Similar marketing services can be expanded to the commercial customers. Financial analysis including pro-forma statements can be provided as part of a loan package. This service is not only an effective marketing tool, but can also generate additional fees to the bank. Since banks already have information on existing customers when loans are made, the additional cost is

minimal. Proper investigation of the legal implications of this service, of course, should be made before the introduction of this service.

In addition to the obvious examples, other innovative uses of microcomputer technology in marketing will be conceived and utilized as more banks realize the potential.[6]

F. Bank Communication

In addition to the many potential applications of the microcomputers in information processing and decision aiding discussed above, microcomputers can be used as an effective information transmission device. Such communication can be both internal within the bank and external to parties outside the bank.

With the proper hardware and software interface, memorandum or letters can be sent via the micros to all relevant parties with the banking organization. For example, memos from the head office can be sent to all or select branches of the bank. Similarly, information can be dispatched to all micros in banks within a holding company within a short period of time. Such practice can greatly reduce processing time and is especially important when time is of the essence. For example, the head office can send market rates of various deposit accounts instantaneously when needed. With proper software and network design, the bank can utilize this capability to enhance funds management.

External communication via a microcomputer is not only feasible, but probably necessary in the future, especially for small and medium-sized banks. For example, the Federal Reserve Bank in San Francisco has recently introduced a new service, Fed Line, to financial institutions. Fed Line allows on-line access to the Fed's mainframe computer for services such as funds transfer, cash ordering, transactions of government securities, and exchanges of economic information. To induce participation, the Fed is leasing to the

participant an IBM PC at a monthly cost of $175, which includes a service contract (see Hewes [1982]). Such a cost effective system may well be available to all banks in the U.S.

Through personal contact, we are also aware that there is significant interest in exploring the usage of microcomputers by regulatory authorities.[7] We would not be surprised that statistical reporting including call reports may be transmitted via microcomputers.

Banking from home may be another aspect of external communication where the bank may effectively utilize the microcomputer. In addition to the normal banking transactions that can be conducted via a micro system, the bank can provide the customer certain customized services discussed in the section under Bank Marketing. With the increasing households which own a microcomputer, this possibility may be common place in the near future.[8]

III. Summary and Conclusions

The 1980's will be a decade in which commercial banks must operate efficiently in order to be profitable and survive the heightened competition that banks appear likely to face. The microcomputer and appropriate software are vehicles which appear capable of assisting banks in meeting this formidable challenge. We found microcomputers would probably assist bank managers effectively in nearly all aspects of bank management. Relatively inexpensive machines and "user friendly" software are becoming increasingly available. Perhaps the major constraints to achieving efficiencies from the microcomputer are a lack of knowledge of potential applications and shortcomings in meeting the information requirements for such applications. This paper identifies banking areas in which microcomputers should be efficient and discloses the

information requirements for effective microcomputer applications in these areas.

The six areas in which microcomputers should prove cost-effective are: 1) strategic management, 2) specific functional areas as lending, investments and funds attraction, 3) bank operations, 4) bank consulting services, 5) bank marketing, and 6) bank communication.

Financial statement forecasting models are an area of strategic planning in which microcomputers are beginning to be widely used because the financial information required is readily available and "what if" assumptions are relatively easy to understand. Strategic optimization planning models have potential for attaining even greater efficiencies. Unfortunately, the needed information -- e.g., some required constraints -- is often not available and bank managers appear to have a hard time interpreting the models used.

There is widespread potential for microcomputer applications in bank functional areas. For example, in the lending area, credit analysis, loan pricing, and customer profitability analysis seem to be natural microcomputer applications. Lack of information in a usable form is a drawback. Microcomputers are already widely used in the investments area. Cost efficient software is already available for security selection, bond swaps, etc. Recent regulatory and legislative changes have introduced several complex deposit and borrowing forms which often can be meaningfully managed with the help of microcomputers.

Similar conclusions were reached for applications and information needed in other areas of banking. We, therefore, conclude microcomputers offer tremendous potential for more efficient operations of commercial banks in many areas in coming years. Our research interest resulting from this conclusion includes a survey of actual and desired uses of microcomputers in a selected

sample of banks and a matching of existing and potential software and hardware with probable areas of bank usage.

FOOTNOTES

[1]A survey conducted by MicroBanker, a private firm specializing in microcomputers, estimated that "any banker" could learn to use a microcomputer with between four and forty hours of self-instruction (see Long [1982]).

[2]For a survey of recent development and usage of these planning models, see Cohen, Maier and Vander Weide [1981]. While the majority of the dynamic balance sheet management models are certainty models, some explicit incorporation of uncertainty into mathematical programming models has been achieved and used. These approaches include multistage stochastic programming with recourse (see Lane [1974], Cohen and Thore [1970], Aghili, Cramer and Thompson [1975]), chance-constrained programming (see Charnes and Thore [1966]), and adaptation of Markowitz's efficient frontier in portfolio management (see Brodt [1978] [1979]).

[3]This section of our analysis draws heavily from information provided in the excellent survey article, "Recent Development in Management Science in Banking," by Cohen, Maier and Vander Weide [1981].

[4]For example, Lane [1978] has developed and implemented a model in the International Bank for Reconstruction and Development based on efficient frontier analysis.

[5]Long [1982] reports that Financial Dynamic Computing (River Forest, IL) provides such softwares for financial institutions.

[6]For example, Columbia Savings and Loan in Denver uses a video disc and a TV screen controlled by a microcomputer to present financial products of the institutions. See Long [1982].

[7]For example, we learn that some staff members of the Comptroller of the Currency are studying the application potentials of various microcomputers in bank examinations.

[8]In fact, some banks in conjunction with videotex network providers have already been experimenting with various home banking services. See Kent [1983].

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