A DECISION SUPPORT MODEL FOR THE CASH REPLENISHMENT PROCESS IN SOUTH AFRICAN RETAIL BANKING

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ABSTRACT

A scientifically-based decision-making procedure for determining the amount of cash to be held at a cash point of a retail bank at any time without compromising customer service levels or incurring undue cost was developed. A typical retail bank branch's total withdrawal and deposit patterns were investigated. The cost parameters relevant to the cash replenishment process were quantified. Alternate policies were developed to significantly reduce the cost of inventory and the average amount of cash carried. By using the model, it was shown that the cost of carrying cash inventory could be reduced by 13 per cent and the average cash inventory by 52 per cent.

OPSOMMING

'n Wetenskaplik-gefundeerde besluitnemingsprosedure is ontwikkel om te bepaal hoeveel kontant gehou moet word op enige tydstip by 'n kontantvoorsieningspunt van 'n handelsbank sonder om kliëntediens te kompromitteer of om onnodige koste aan te gaan. 'n Tipiese handelsbanktak se totale onttrekkings- en depositopatrone is ondersoek. Die kosteparameters relevant tot die kontantaanvullingsproses is gekwantifiseer. Alternatiewe beleide is ontwikkel om 'n betekenisvolle voorraadkostevermindering asook 'n vermindering van die gemiddelde hoeveelheid kontant wat gedra word, te behaal. Deur die model te gebruik, is daar getoon dat die voorraaddrakoste met 13 persent en die gemiddelde kontantvoorraad met 52 persent verminder kon word.

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1. BACKGROUND

Retail financial services have been evolving at a great pace in the recent past. Issues that have had to be addressed include [KPMG 1]:

- Declining margins;
- consolidation;
- increasing shareholder demands;
- new regulatory pressures;
- growing complexities and costs of technology;
- new market entrants; and
- higher customer expectations.

In this changing global financial services market, the role of retail banks is continuously being redefined, specifically with reference to the provision of cash to a global society, which despite the move towards a cashless world, continues to prefer cash as a method of payment in concluding transactions. It is claimed that 50% of all payments world-wide are made with notes and coin. The question of cash remains central to how banks perceive their roles and strategies as well as how they are perceived by their customers. [De La Rue 2]

Given the fact that retail banks have to provide for the needs of their customers with regard to cash, the following illustrates the scope of the problem:

- Retail banks have to carry certain amounts of cash at branches, agencies and in automated teller machines (ATM's), but in doing so incur certain costs.
- The nature of the cost of providing cash facilities, has to a certain extent, been obscured due to a reluctance to regard cash as an inventory item. This unwillingness is most probably the legacy of accounting practice, which must be appreciated.
- The cost elements involved in providing cash facilities *inter alia* include holding cost, insurance cost, transportation cost, processing cost and shortage cost.
- Various other factors exacerbate the cash replenishment problem, for example, unpredictability in demand patterns and unreliability in supply lead time.

The result of the above is that retail banks tend to hold excessive cash at their various cash points (be it a branch, agency or ATM). If a holistic view of the problem is taken, identifying the true nature of all of the costs involved, without overemphasizing a single element, it would lead to a reduction in the amount of cash held at a cash point and it would minimise the unnecessary movement of cash, an activity that hardly adds value from the customer's perspective. It is claimed that *"cash frustrates bankers because the customer is reluctant or unwilling to pay for cash services"* [De La Rue 2].

Although the problem of providing cash in the correct quantities, and denominations, and at the right time, is common world-wide, a number of factors specific to the Republic of South Africa contribute to the extent and scope of the problem locally. Oosthuysen [3] states that South African banks in general are faced with a number of challenges such as increased local and international competition, an increase in fraud and money laundering activities, bank robberies, customer resistance to excessive price increases as well as aggressive and innovative marketing initiatives.

During an interview with representatives of De La Rue Cash Systems, UK, the following claims were made to illustrate the ignorance which exists globally with regard to the problem of optimising cash provision:

- 20% of all retail banks world-wide are aware of the problem of optimising cash provision and are attempting to address it.
- 30% of all retail banks world-wide are considering addressing the problem, but are not yet doing it.
- 50% of all retail banks are not even aware of the problem or of the benefits that may accrue if the problem is addressed.

The increasingly competitive and complex environment of retail financial services has compounded the focus on key profit drivers and has led to fundamental questions about the management and exploitation of distribution channels [KPMG 1]. It is important to note the two major sources of profit for retail financial service institutions. The first source of revenue is loan activities, *i.e.* the difference between income on funds lent and the cost of deposits. The second source is commission and the fees recovered for financial services rendered [Falkena 4]. From the above, it is obvious that the cost of deposits detracts from the first source of income. Therefore if anything can be done to reduce the cost of deposits, it will lead to an increase in profit.

In a thesis submitted to the Department of Applied Accountancy, UNISA, in 1995, Oosthuysen [3] investigates the problems with current management information reporting in South African banks, which is not timeous and lacking in reliability. He states, *inter alia*, that information regarding the cost of a product and the profitability of a product is not readily available. The provision of cash is but one of the products (or services) provided by retail banks. As stated by De La Rue [2]: *"As banks attempt to unbundle costs to identify cross-subsidy across product lines, the cost of cash has come in for increasing scrutiny"*. Therefore any investigation into the cost of providing this service will be to the advantage of the industry.

The main objective of the research undertaken was therefore to establish a scientifically-based decision-making procedure for optimising the amount of cash to be held at a cash point (be it branch, agency or ATM) at any time without compromising the customer service level or incurring undue cost. To reach the objective, the problem was divided into a number of subproblems, each having its own objective. The subproblems were as follows:

- To determine the cost parameters describing the nature of the problem of cash provision in a South African context;
- To investigate the characteristics unique to the South African retail banking environment;
- To determine the nature of the demand distribution (a function of deposits and withdrawals) for a cash point;
- To develop a forecasting method appropriate for the retail banking environment in South Africa;
- To investigate the existing order policies used by retail banks, as well as alternative order policies, with the aim of improving the process of cash replenishment, as represented by typical branch of a South African retail bank.

The aim was to develop a generic model, based on the investigation into these subproblems, which may be used to improve the cash replenishment process at branch level for retail banks in South Africa.

2. RESEARCH METHODOLOGY

To investigate the cash replenishment problem the cooperation of one of the leading retail banks in South Africa was obtained. A typical branch was selected. The total withdrawal and deposit patterns as well as the ATM withdrawal patterns for a three month period during 1998 were investigated. The cost parameters relevant to the cash replenishment process were quantified. The approach followed was based on the classical inventory theory where the total cost of carrying inventory comprised three cost categories, *i.e.* storage cost, supply cost and shortage cost. Since the banks do not quantify the shortage cost, various assumptions regarding the scope of the shortage cost had to be made.

The next step was to determine the cost of the existing order policy followed by the branch. This figure was used as a benchmark once alternate policies were investigated. The investigation resulted in alternate policies which significantly reduced the daily cost involved in carrying inventory as well as reduced the average amount of cash carried at the branch. By reducing the average cash inventory level, the risk factor related to bank robberies was significantly reduced.

It was also shown, that the branch should consider using an appropriate forecasting method, since once forecasting was combined with an appropriate order policy, it was possible to reduce the cost of carrying cash inventories even further.

In conclusion, the research report suggested an implementation plan to be followed at branch level pointing out that certain changes to information systems were required. In addition, training needs were identified to enable the branch operations manager together with his/her support staff to successfully use the decision support model.

3. PROBLEM DESCRIPTION

A part of the business conducted in retail banking concerns the provision and receipt of cash as required by the customers in turn to conduct their business, whether it is private or commercial in nature. A driving force in the continued high usage of cash despite the development of various other methods of payment is the immediacy and convenience of cash for the individual [De La Rue 2]. In studying the cash replenishment problem in retail banking, the specific characteristics of the situation determine the nature of the problem.

In the South African banking system cash replenishment at branches, agencies and automated teller machines (ATM's) of retail banks, takes place on a daily basis within the following framework:

- Cash replenishment occurs by means of a single delivery per day at the normal reorder cost. An interim delivery is possible, but the order cost is significantly higher in such a case.
- Fourteen different denominations (coin and notes) represent the South African currency in circulation.
- A shortage situation is highly unacceptable at a branch or agency, due to the perception formed in the mind of the customer and the ripple effect this may have. At an ATM, a shortage may occur, and is tolerated by the customer, since it is accepted that an ATM may run out of cash from time to time (especially when the location is remote from a branch or agency). Often the customer is unaware of the exact reason for a transaction not being processed at an ATM and therefore accepts a shortage situation.

Cash balances held in branches, agencies and ATM's of a bank represent a sizable amount of unproductive capital and it is therefore in the interest of the bank to reduce such amounts to as low a level as is practical and possible. As stated by Derwa [5]:

> *The problem is part of the general class of stock problem. The question is one of determining the amounts to be delivered and the delivery dates that will minimise the total cost, which is the weighted sum of the costs of storage, supply and shortage.*

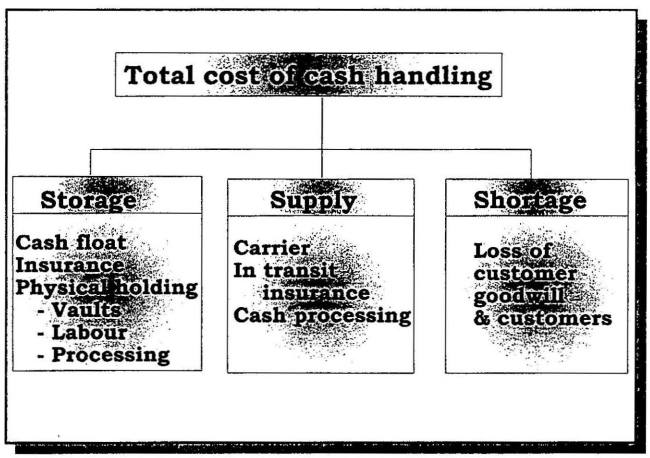
Johnson [6] makes the following statement when describing the traditional bankers' approach to cash: *"Cash is certainly an expensive commodity, but most bankers contend that it is an inevitable expense in the current system."* Wagner [7] provides an apt description of the insensitivity in business to the relevance of inventory management, which indeed is the case in retail banking. The employees in this environment in South Africa show an ignorance of the scientific approach to inventory management when cash balances are discussed. Not only is ignorance evident, an unwillingness exists to treat cash as an inventory item. As Miller & Orr [8] state: *"It may be a little startling at first to think of your firm's cash balance as just another inventory – an inventory of dollars so to speak – but is it really so farfetched?"*

4. MODEL DEVELOPED

Figure 1 shows the cost components when carrying cash in a situation at a cash point of a retail bank.

Figure 1

The cost components of cash handling



Based on the above classifications and various deductions based on whether the amount of cash held is in fact sufficient for one trading day or not, it is possible to construct a conceptual mathematical model for the total cost of handling cash in a branch, agency or ATM of a retail bank. All variables used in the model are as defined by Naddor [9] and, if required, definitions may be found in the reference mentioned. The model, based on the classical inventory theory, is as follows:

For $\sum Q_i < Q_O$, the following holds:

$$C\ (Q_i) =$$

$$C_{10}+(c_{11}+c_{12}+c_{13})\sum_{i=1}^{14} Q_i-\frac{C_{20}}{Q_O}(\sum_{i=1}^{14} Q_i)+C_{20}+c_{31}\frac{D}{Q_D}-\frac{C_{32b}}{Q_b}(\sum_{i=1}^{14} Q_i)+C_{32b}+c_{332}\frac{D}{Q_D}+c_{34}(\sum_{i=1}^{14} Q_i)$$

For $Q_O \leq \sum Q_i$, the following holds:

$$C\ (Q_i) =$$

$$C_{10}+(c_{11}+c_{12}+c_{13})\sum_{i=1}^{14} Q_i+c_{31}\frac{D}{Q_D}+\frac{C_{32a}}{Q_a}(\sum_{i=1}^{14} Q_i)-C_{32a}+c_{331}\frac{D}{Q_D}+c_{34}(\sum_{i=1}^{14} Q_i)$$

It must be stressed that the above merely represents a conceptual model for which the various cost parameters needed to be determined. Once the parameters were known, it was possible to investigate the model in depth to establish the optimum of the problem to, for example, interim deliveries. At present in South African banking circles, it is assumed that a single daily delivery provides the optimum solution to the cash replenishment problems of a branch, agency or ATM.

5. FORECASTING AT BRANCH LEVEL

It is appropriate at this point to consider the characteristics of a good forecast before discussing various forecasting methods suited to the particular situation. Nahmias [10] lists the following characteristics of forecasts:

- They are normally wrong, therefore the planning system should be sufficiently robust to be able to react to anticipated forecast errors.
- A good forecast is more than a single number; it should include some measure of anticipated forecast error.
- Aggregate forecasts are more accurate.
- The longer the forecast horizon, the less accurate the forecast will be.
- Forecasts should not be used to the exclusion of known information; cognisance should be taken of factors influencing future demand not represented in the historical data.

If these requirements are related to the branch of a retail bank, it has specific implications for the forecasting technique used. Firstly, the fact that the forecast will not be correct, implies the use of some safety stock to cover for expected errors. Secondly, the safety stock calculation should be based on the anticipated forecast error. In the third place, forecasting total daily withdrawals, deposits and ATM withdrawals would represent aggregate forecasts, which would result in a smaller error than forecasting individual transaction values or even demand for specific denominations. In the case under review the forecast horizon is relatively short, *i.e.* two days for normal orders and one day for special orders. Inclusion of known information would imply that knowledge of a public holiday and the impact that may have on the demand at the branch should be considered, or that the impact of the December school holidays on activity levels at the branch should be taken into account.

Stevenson [11] states further that a properly prepared forecast should fulfill certain requirements:

- The forecast should be timely.
- The forecast should be accurate and the degree of accuracy should be stated.
- The forecast should be reliable and work consistently.
- The forecast should be expressed in meaningful units.
- The forecast should be in writing to ensure that all parties involved use the same information and to permit an objective basis for evaluating the forecast once actual results are available.
- The forecasting technique should be simple to understand and to use.

The implications of the above for the branch are the following: The forecast should be available in time for the operations manager to use when placing the cash order with SBV (the organisation responsible for cash distribution to retail banks in South Africa). Monitoring the forecast to prove or disprove its accuracy and reliability, and therefore usefulness would be necessary. Finally, the importance of having a simple system which is easy to use cannot be overemphasised.

Based on the reasoning put forward in the previous two paragraphs, sophisticated methods, such as the Box-Jenkins model, were deemed to be unsuitable. Given the particulars of the situation, a simplistic, user-friendly approach providing a rapid response was regarded as the most appropriate method.

Winter's method for forecasting demand, where the demand patterns exhibit some form of seasonality, was regarded as a possibility, since in addition to compensating for seasonal behaviour, it also provides for a trend component [Montgomery & Johnson 12]. In addition, Holt's method which combines exponential smoothing with a trend, was considered [Winston 13]. Finally, in an attempt to consider as many options as possible, the forecasting module of *HOM Operations Management Software for Windows®* [Moses 14] was used to evaluate 16 different approaches. The methods investigated included simple exponential smoothing, FIT smoothing (or double exponential smoothing also known as Holt's method), trend regressed exponential smoothing, simple average, moving average and Winter's method. Since seasonality and a trend component were present in all three data series, two approaches to treating the seasonality and two methods for incorporating the trend component were investigated respectively.

Two techniques were used to calculate seasonality for each forecasting method investigated, *i.e.* simple seasonal relatives (SSR) and moving seasonal relatives (MSR). In the second case, the seasonal relative is an average based on, for example, the preceding and following seasonal weights, whereas the first approach merely determines the weight for that particular season [Stevenson 11].

Two approaches to calculating the initial value of the trend component were used for each forecasting method. The first (default) approach used an initialisation value of zero, whereas the second approach used a regressed value for initialisation purposes. The regression was carried out over the starting and ending periods of the data [Moses 14].

The software has the capability to find the best option from five methods, *i.e.* exponential smoothing, FIT smoothing, exponential smoothing with a regressed trend, simple average and moving average. The selection of the best of the methods is based on the forecast error. In addition, the software is capable of optimising the values of the smoothing constants, where applicable. This is achieved by minimising the root mean square error (RMSE). [Moses 14].

6. ORDER POLICIES AT BRANCH LEVEL

In developing alternate order policies for the branch, simulation runs were performed to evaluate the cost of the proposed policies. Before this could be done, a series of random numbers representing the total demand and total withdrawal patterns at the branch were generated based on appropriate probability distributions.

Using the *Input Analyzer* function of *Arena*® [Kelton 15], various distributions were fitted to the available data describing demand and withdrawal patterns. *Input Analyzer* fits a number of different probability distributions, providing an indication of the goodness of fit. Since the Weibull distribution provided an acceptable fit to both the deposits (squared error = 0.022) and withdrawals (squared error = 0.0125), it was selected to represent the distributions for both deposits and withdrawals. Kelton [15] states that the Weibull distribution is particularly useful to represent non-negative values that are skewed to the left. The suitability in this particular situation is confirmed by Figures 2 and 3.

Figure 2: Histogram of amounts deposited daily from April to June 1998

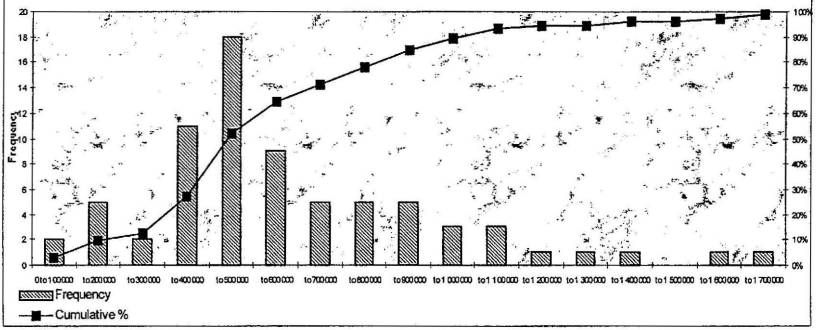
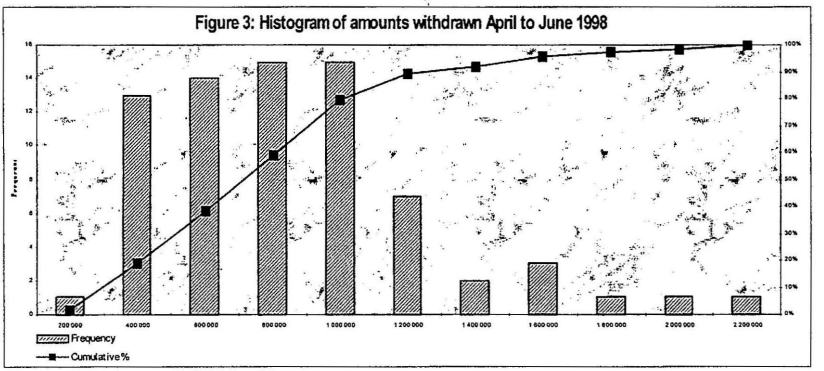


Figure 3: Histogram of amounts withdrawn April to June 1998



As a first step to simulating conditions at the branch, 960 data points describing deposits and total withdrawals per day were generated from the fitted probability distributions. The differences between the daily deposits and total withdrawals generated, were calculated. The normal distribution was fitted to these differences, providing a square error of 0.0033 - indicating that the differences were normally distributed as would be expected. This data string was used as an initial test to investigate the sensitivity of the total cost of holding cash inventory to changes in certain parameters, for example

safety stock, reorder point, order quantity and also the impact of an estimate of the shortage cost.

The second step in the investigation was to test the best alternatives from each simulation run against the actual total withdrawal and deposit patterns obtained from the branch, and to compare the cost of the proposed policies to the actual cost of the existing policy.

7. RESULTS ACHIEVED

Table 1 compares the existing approach followed at the branch (which is mainly experience-based and largely of a random nature) to the proposed method based on the research at that particular branch. It was shown that the daily cost of carrying cash inventory could be reduced from R2 729 per day to R2 371 per day. This represented a 13 per cent bottom line cost reduction at the branch or R358 per day. If this result is extrapolated for similar branches within the portfolio of this particular retail bank, the potential annual saving exceeds R8 000 000.

It is important to note that some elements of the research would apply at any branch of this retail bank and for that matter, probably at any retail bank branch in South Africa, for example the order cost or the processing cost . However, some elements are particularly branch specific such as deposit and withdrawal patterns and therefore would have an impact on the most appropriate forecasting technique to use for each of these.

Table 1

The proposed model compared to the reality at the branch

Feature	Method used at branch	Proposed method
Average cash on hand	R2 009 264	R970 858
Minimum cash on hand	R736 043	R215 343
Maximum cash on hand	R2 751 331	R1 690 575
Reorder point	From R500 000 to R1 500 000	R300 000
Cash holding cost/day	R2 729	R2 371
Reorder quantity	From R250 000 to R1 300 000	R750 000
Safety stock	R500 000	R200 000
Special order size	R500 000 (minimum)	R500 000
Number of normal orders	16[1]	16
Number of special orders	1	1
Number of shortages	0	0

1 On six occasions these orders concerned coin rather than notes

8. LIMITATIONS OF THE STUDY

The study was limited to an investigation at one particular branch of a leading South African retail bank. The figures used to describe cash movements at the branch obviously were of an extremely sensitive nature and were fairly difficult to obtain due to the way in which transactions are reported. The accuracy of the data provided by the branch could not be verified, but had to be accepted at face value. Although a particular case was investigated, a concerted effort was made to point out how the methodology may be used in the generic situation.

In addition changes at SBV, the sole supplier in this particular case, as regards ownership may have a bearing on the supply cost structure. Rumours of a management buy-out or a take-over by the South African Reserve Bank in contrast to the current ownership may impact directly on how the cash is supplied. Some of the constraints adhered to by the branches at present, for example a single delivery per week is preferred, may then be challenged.

9. CONTRIBUTION TO THE KNOWLEDGE BASE

As pointed out earlier, the research was limited to a particular branch of a South African retail bank, the study proved the applicability of industrial engineering principles in a service environment, where the added value of having the optimum cash amount available when required would impact directly on the bottom line of the bank and thereby achieve a cost reduction which can only enhance share-holder value. In the changing environment confronting retail banks in South Africa, enhanced share-holder value is of the utmost importance to increase competitiveness and long-term survival.

10. FUTURE RESEARCH

It would be prudent at this point to indicate possible further research opportunities emanating from the research. It is quite clear that more work needs to be done to distinguish between branch-specific and generic factors impacting on the cash replenishment problem. In addition some elements which were varied on an *ad hoc* basis in this instance may be quantified in a scientific way. Examples that come to mind include safety stock levels, service levels, the determination of the trading area and many more. This was but a first attempt to show the advantages of approaching the problem in a more scientific way than is at present the case.

Finally, the role of industrial engineering in the service environment may no longer be challenged and the particular role in the retail banking environment should be a *fait accompli.*

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