

CHAPTER 4

Estimating the cost parameters relevant to cash replenishment

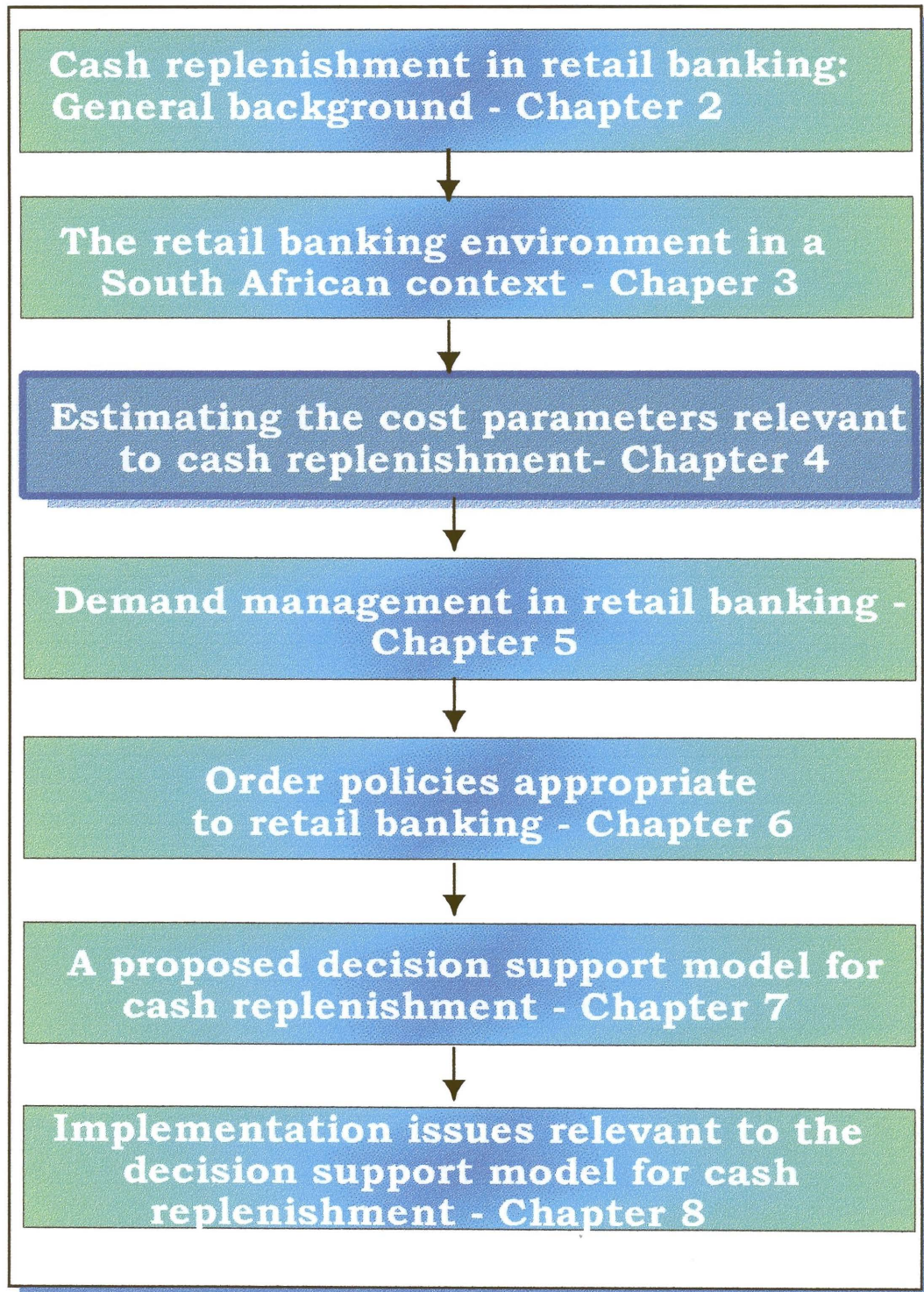
4.1 Introduction

Chapter 2 proposed a mathematical model to represent the cost elements involved in the replenishment of cash at a branch of a retail bank. To test the model, a typical branch of a leading South African retail bank was used. In the following paragraph, the specific characteristics of the situation at this particular branch are explained, where after the cost parameters discussed in Chapter 2 are quantified. Figure 4.1 shows the relevance of Chapter 4 to the research.

It would be appropriate at this point to comment briefly on the need for better cost information in the retail banking environment. It is a known fact that the operating expenses in retail banking are continuously increasing, resulting in a decline in profit margins. This situation is however not new. In a book published in 1970, the author John Walker in the foreword states the following (Walker 1970:iii): *“This book was written out of a conviction of mine that bank cost accounting procedures ... do not provide management with the type of information needed for decision making purposes.”* In addition, a compounding factor has been the recent rapid increase in South African interest rates (and subsequent decline) as proposed by the previous president of the South African Reserve Bank, Dr Chris Stals in his last presidential address (Sake-Beeld 1998c:1). A rising inflation rate will also prevent interest rates from being reduced significantly in the near future (Sake-Beeld 1998b:1).

Figure 4.1

The structure of the report indicating the relevance of Chapter 4





From the above it is quite clear that decision-making will be facilitated if the true cost of holding cash is determined. Oosthuysen (1995:124-125) proposes a product costing methodology for a commercial bank, but although this methodology enhances decision-making from a head office perspective, it does not facilitate decision-making at the branch level, such as optimising the amount of cash carried by the branch.

4.2 Case background

Permission was obtained from one of the retail banks in South Africa to make use of the information pertaining to a branch, which would represent one of the more complex situations to be found at a typical branch in the country. For obvious reasons, the information is extremely sensitive and therefore the bank and branch will remain unnamed, as per prior arrangement with the bank.

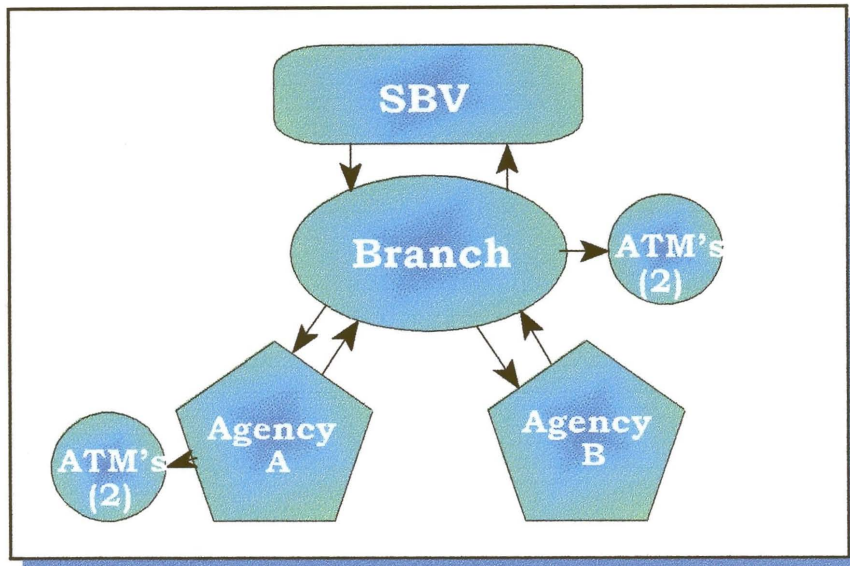
This specific branch serves both a commercial and a domestic customer base. The branch has two agencies and four automated teller machines which are dependent on it for the provision of cash. Two of these ATM's are located at the branch, while the other two are located at one of the agencies. The other agency does not have an ATM. Appendices A and B show the total deposit and withdrawal patterns at the branch and its two agencies for the period April to June 1998. The following information regarding savings and cheque accounts at the branch during the time of the investigation was obtained:

- Number of savings accounts: 7 530
- Average total monthly balance on savings accounts: R18 183
- Number of cheque accounts: 3 877
- Number of cheque accounts showing a credit balance: 2 768
- Number of cheque accounts showing a debit balance: 1 109
- Average total monthly credit balance on cheque accounts: R7 734 768
- Average total monthly debit balance on cheque accounts: R5 202 739

Figure 4.2 provides a graphic representation of cash movements to and from the branch. The process of supplying a branch with cash was detailed in Figure 2.2. This would represent the total picture where the branch does not have agencies. However, in a case where the branch is responsible for one or more agencies, the situation becomes more complex.

Figure 4.2

Cash movements to and from branch



Delivery from the cash centre, SBV, is possible once per trading day at the normal delivery cost. However, the supply lead time is two days. An order must be placed with SBV before 9:00 for delivery two days later. Delivery on the assigned day may take place any time between 7:45 and 20:00. Should the branch realise that more cash is needed for a specific day, a special order may be placed before 13:00 for delivery that same day. A special delivery is more expensive than a normal delivery. Special deliveries almost always arrive after 17:00. The minimum amount by special delivery is R500 000. A special delivery is an unusual occurrence – this branch has only had one special delivery during



the three month period under review. A special delivery may only be arranged once it has been authorised by the regional head office – the operations manager at the branch has to obtain such authorisation.

When ordering cash from SBV, coin may only be ordered on a Friday. Notes may be ordered for any trading day. When ordering notes from SBV, the minimum order is set at 200 notes of any denomination, for example 200 R20 notes or 200 R200 notes. The branch, as a rule, attempts to order cash only once a week, but this is not always possible, particularly at the end of the month. Experience has shown that deliveries for the last Friday of the month invariably arrive too late on the day, therefore the branch has taken the decision to arrange for the cash to be delivered on the last Thursday of the month. Appendix F shows the schedule of SBV deliveries for the period April to June 1998. Obviously, since coin may only be ordered for delivery on a Friday, the decision to have notes delivered on the Thursday will lead to two deliveries that week, as for example at month end in June 1998.

As a rule the branch does not return notes to SBV, unless the notes are deemed to be unfit for further use or if a denomination switch is required. This is a highly unusual occurrence. During the period under review a denomination switch took place on only one occasion, *i.e.* on Friday, 22 June 1998 (see Appendix F).

Although money is moved from the branch to its agencies, no money may be transported between branches. Transportation between the branch and its agencies occurs twice a day – once early in the morning to deliver cash and once in the afternoon to return surplus cash. Whereas SBV is responsible for transporting cash to the branch, two other security companies are responsible for moving the cash between the branch and its agencies.

Agency B is quite small and serves a finite population of employees at a particular business. Agency B does not keep any notes overnight, but may keep coin. Therefore, notes left at the end of the trading day are returned to the



branch. This agency is also closed on a Saturday. Agency A, in contrast, is open Monday to Saturday. It has a pattern of large deposits, therefore, the branch normally only sends an amount of approximately R26 000 in the mornings to the agency. After trading, the agency may not keep more than R360 000 overnight – it therefore returns any excess to the branch. Returns typically amount to approximately R200 000. Cash movements between the branch and its agencies from April to June 1998 are shown in Appendix F.

The ATM's are filled by staff members at the branch and the agency respectively. No cash is ever removed from an ATM for use in the branch or agency. Cash deposits at the ATM are removed and are then treated as ordinary deposits in the branch or agency at a cashier. Withdrawals from an ATM on a Sunday, are not treated separately, but added to the Monday withdrawals. Appendix C1 shows cash movements at the four ATM's which are the responsibility of the branch and Agency A.

4.3 Cash holding cost parameters

In determining the various cost parameters, Figures 2.2 and 4.2 serve as background throughout. The various steps in replenishing cash were described in these figures. Each of the three elements, C_1 , C_2 and C_3 , will be discussed separately, whereafter the proposed model of Chapter 2 is evaluated.

4.3.1 Storage cost (C_1)

As discussed in paragraph 2.3.2.1, the storage cost consists of a fixed component as well as a variable component. The fixed cost component (C_{10}) is discussed first.

4.3.1.1 The fixed component of storage cost

The fixed cost component (C_{10}) represents expenditures made directly to facilitate the cash holding process. These include factors such as expenditures for special



security entrance doors (known as a mantrap door system) to the cashier area in the branch or agency, alarm system installations, a closed circuit television observation system, under-counter safes for each cashier, the main safes, the safety screen installations in front of the cashiers' desk, special protection of the ATM backrooms as well as security guards employed by the branch or agency. Since the branch under review has recently moved to new premises, the security arrangements at the branch are state of the art.

In addition to the security expenditures, the branch also incurs some other fixed elements attributable to the holding of cash. These include a counting machine as well as the rent payable for the space utilised by the cash in the branch or agency. Since the space provided is purpose-built for the holding of cash, it can not be used for other purposes.

To determine the scope of C_{10} , the safety expenditure figures shown in Table 4.1 were obtained from the branch. These figures include expenditures at the two agencies.

Table 4.1
Initial safety expenditures

| | |
|---|-------------------|
| Closed circuit television installation | R 75 000 |
| Alarm system installations (2 each @ R22 500) | 45 000 |
| Installation of mantrap door (2 each @ R69 000) | 138 000 |
| Cashiers' safety screen (3 each @ R60 000) | 180 000 |
| Main safes (2 each @ R 12 500) | 25 000 |
| Cashiers' safes (10 each @ R 9 500) | 95 000 |
| Protection of ATM backroom (2 each @ R5 500) | 11 000 |
| Automated teller machines (4 each @ R180 000) | 720 000 |
| Counting machine (5 each @ R12 900) | 64 500 |
| TOTAL | R1 353 500 |



In addition to the initial expenditures attributable to the handling of cash, certain running expenses are incurred which may also be attributed to the holding of cash. The first is the cost of the security guards and the second is the rent payable for floor space dedicated to cash holding activities. The rent cost is considered to be a fixed monthly amount, since the space allocated to the holding of cash is dedicated to that activity and can not be used for anything else. It is therefore not dependent on the amount of cash carried by the branch. The figures obtained from the branch are shown in Table 4.2.

Table 4.2
Running monthly expenses

| | |
|--|---------------|
| Security guards (3 each @ R 1 550 per month) | 4 650 |
| Rent: Branch @ R 70/m ² per month | |
| Cashiers' area behind safety screen (contains safes) -28m ² | 1 960 |
| ATM backroom -20m ² | 1 400 |
| Agencies @ R 28.44/m ² per month | |
| Cashiers' area behind safety screen (contains safes) -39m ² | 1 110 |
| ATM backroom -9m ² | 256 |
| TOTAL | R9 376 |

The total value of the fixed component of storage cost is R1 353 500. The value of C_{10} as depicted in Figure 2.4 has to be expressed as a daily figure, since the cost on the vertical axis has the unit of Rand per day. Depreciation is done over a period of three years, therefore if straight line depreciation is assumed, the value of the fixed component of C_{10} may be rounded to R1 237 per day. The monthly component is R9 376, which expressed as a daily figure, based on 30 days per month, may be rounded to R313.

The value for C_{10} for this particular branch is therefore R1 550 per day.



From the above it is obvious that the total value of C_{10} is branch specific and should be established separately for each branch.

4.3.1.2 The variable component of storage cost

As pointed out earlier, the variable component of C_1 consists of three distinct elements. The first, c_{11} , is the cash float cost incurred by the branch. At present, the branch pays an interest rate of 15,5% per annum on every Rand carried by the branch overnight. This will include any amount kept overnight at the agencies or in the ATM's.

The second variable element of storage cost is insurance, c_{12} . The cash held by this branch is not insured, since the bank policy determines that amounts in excess of R5 000 000 only are insured. At no point for the period under review, did the branch carry an amount in excess of R5 000 000. Appendix D1 shows the total daily cash amounts on hand for the period April 1998 to June 1998. The cash amount peaked at R2.73 million during June. Therefore, c_{12} is 0.

The last element of storage cost pertains to the labour cost per unit, c_{13} . The activities represented in this component include removing cash from the safe for use by the cashiers and balancing by the cashiers at the end of the trading day. It does not include preparation of cash amounts to be sent to agencies or the replenishment of ATM's. These elements are included in the determination of C_{31} in a later paragraph. Each cashier is responsible for balancing his/her safe at the end of the trading day. In contrast to the behaviour of the labour cost as proposed in the model in Chapter 2, the labour cost involved is fairly insensitive to the amount of cash remaining at a cashier at the end of the trading day. This activity takes approximately 30 minutes to perform, irrespective of the amount involved. Since the branch and the agencies in total have nine cashiers, the total time spent on balancing is 4.5 hours at an average labour cost of R18 per hour. Therefore, the daily cost is R81. Since it is regarded as fixed rather than dependent on the amount of cash involved, it is denoted by C_{13} in the revised version of Equation 2-3, *i.e.* Equation 4-1.

4.3.1.3 The revised calculation of storage cost

Based on the preceding two paragraphs it is necessary to revise Equation 2-3 proposed in paragraph 2.3.2.1 to calculate the storage cost. The revised expression is as follows:

$$C_1(Q_j) = C_{10} + c_{11} \left(\sum_{i=1}^{14} Q_i \right) + C_{13} \dots \dots \dots (4-1)$$

where C_{10} and c_{11} are as defined earlier, but instead of c_{13} , the labour cost is also regarded as a fixed component, denoted by C_{13} .

When the actual values determined in the preceding paragraphs are substituted into the expression it becomes:

$$C_1(Q_j) = 1550 + (0.155/365)c_{11} \left(\sum_{i=1}^{14} Q_i \right) + 81$$

which reduces to

$$C_1(Q_j) = 1631 + 4.247 \times 10^{-4} c_{11} \left(\sum_{i=1}^{14} Q_i \right) \dots \dots \dots (4-2)$$

Appendix E shows the calculation of the daily cash storage cost, as well as the monthly totals for the three months April to June 1998. The storage cost is in excess of R70 000 per month with the interest cost representing on average a third of the total storage cost.

4.3.2 Shortage cost (C_2)

The banks are hesitant to put a value on shortage cost, since it is extremely difficult to quantify. It will be ignored for the time being, but once the model has been evaluated, the impact of a shortage will be investigated. If the patterns reflecting amounts of cash carried by the branch are investigated (refer to Appendices A and B in this regard, and in particular to the graph in Appendix



B5), it is obvious that a shortage is avoided by carrying high levels of cash. This implies that the banks regard the shortage cost as significant. The impact of the shortage cost on order policy will be discussed further in Chapter 6.

4.3.3 Supply cost (C₃)

Although Chapter 2 identified four elements constituting supply cost, the actual situation is rather different. Firstly, it is necessary to separate the supply to and from the branch by SBV from the transportation of cash between the branch and the agencies, since different carrier companies are involved and the cost structures for the situations differ. Figure 4.2 shows the upstream and downstream movement of cash to and from the branch. Secondly, the order cost and the cash handling cost elements of supply cost are combined in determining the actual cost. This is discussed in paragraph 4.3.3.1. The transportation cost and in-transit cost elements are discussed in paragraphs 4.3.3.2 and 4.3.3.3.

4.3.3.1 The order and cash processing cost elements of the supply cost

Although the proposed model separates order cost and cash processing cost when determining the supply cost, the actual situation allows for these two elements to be combined. Since the time involved in processing cash is fairly short, the assumption is made that the time is constant irrespective of the amount involved, therefore the cost of cash processing is regarded as fixed per event.

However, to allow for the separation of movements upstream and downstream from the branch, Equation 2-6 for determining the order cost element (C₃₁) is revised as follows:

$$C_{31}(Q) = c_{311} \frac{D}{Q_D} + c_{312} \frac{A}{Q_A} \dots \dots \dots (4-3)$$

where c₃₁₁ represents the internal order and processing cost involved when a visit from SBV occurs, c₃₁₂ is the internal order and processing cost regarding



supply of cash to the two agencies, A represents the total demand for cash at the agencies during the planning period and Q_A is the cash amount involved in the trip between the agencies and the branch.

The internal activities involved to arrange for a visit from SBV to the branch are the responsibility of the operations manager at the branch, but may also be performed by the treasury custodian, although the responsibility remains that of the operations manager. This includes reviewing the amount of cash in the branch at the end of a trading day taking into consideration whatever is held overnight at the agencies, as well as the balance in the ATM's. Based on this amount a decision is made whether to place an order for the next day. Since the supply lead time is two days when trading on consecutive days, this implies considering the required amounts for trading two days hence. Obviously a disruption in trading and replenishing due to a Sunday or a public holiday will be considered.

The ordering procedure consists of a telephone call being made and a facsimile message being sent to SBV by the operations manager. In all the total duration of these activities is approximately 10 minutes. The labour cost involved is R45 per hour, therefore the labour cost is R7.50 per order. The cost of the facsimile is estimated at R1, whereas the telephone call of two minutes is estimated to cost R1.50. The total cost to place the order, therefore, is R10.

Internal proceedings when delivery or removal by SBV occurs, take approximately 20 minutes. Again this should be dependent on the cash amount involved in the delivery or removal, but since the period involved is relatively short, an average time is taken. The cost of the labour involved in the process is on average R37 per hour, therefore since two staff members are involved the total labour cost may be rounded to R25 per order.

The total internal order cost, c_{311} , when a delivery or removal by SBV occurs, is therefore R35.



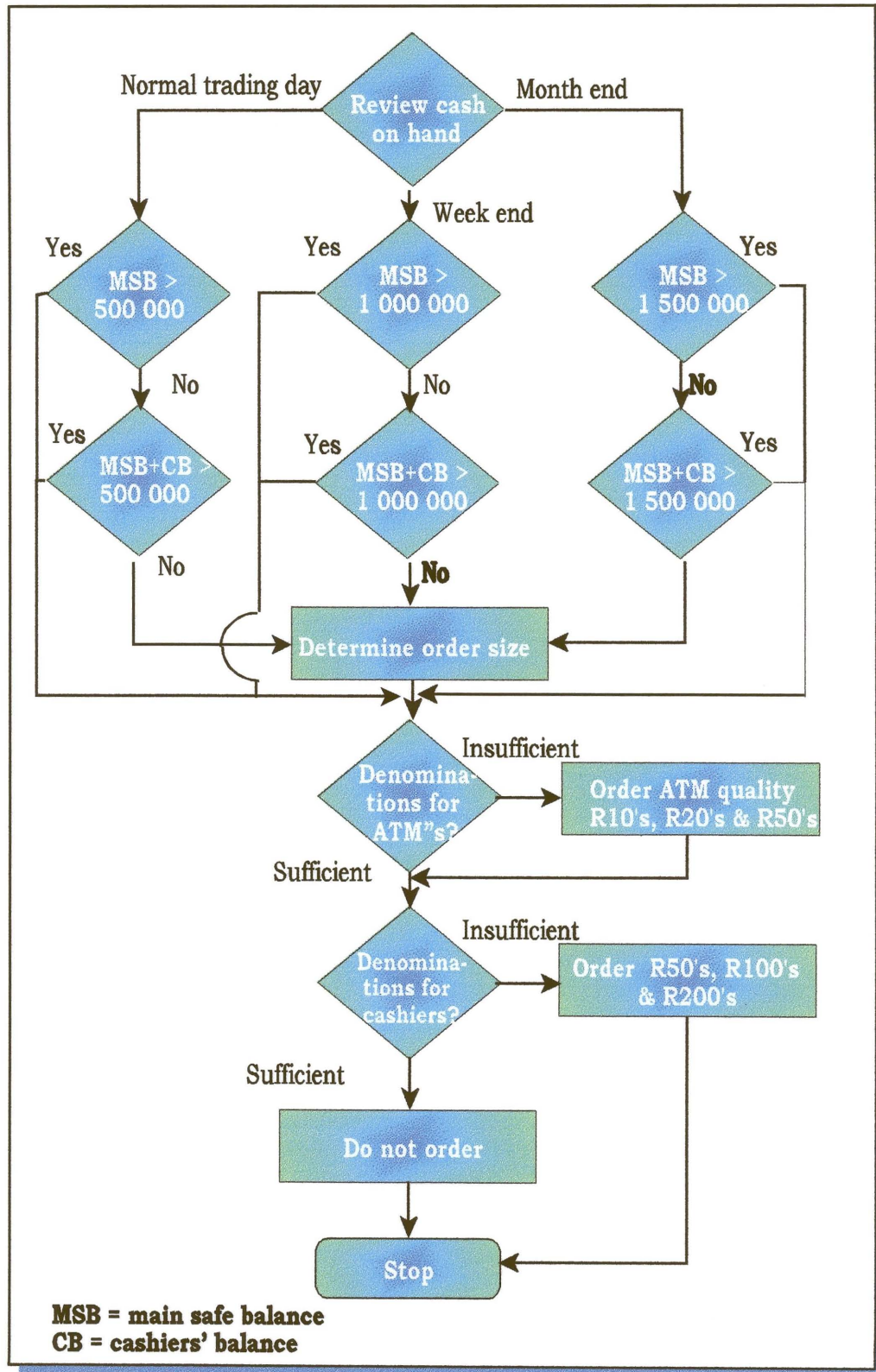
It would be appropriate to comment on the existing order policy followed by the operations manager regarding the placement of orders to replenish, replace or reduce the amount of cash held at the branch. This policy is not formalised in any way, but is based on experience at this particular branch. As a rule of thumb, the amount of cash in the main safe is used as a benchmark. The reasoning behind the policy is depicted in Figure 4.3. Appendix I compares this experience-based policy to actual orders placed, showing that the policy is not adhered to strictly. The policy is investigated in greater detail in Chapter 6.

With regard to supplying the agencies with cash, transportation occurs twice a day – to each agency each morning with a return from each agency every afternoon after trading. The proceedings at the branch and the agency attributable to the movement of cash are mirror images – what happens at the branch in the morning and in the afternoon occurs in reversed order at each agency. It takes approximately 20 minutes for the preparation of each order to be sent to the agencies and 20 minutes when the cash is returned in the afternoon. Once the cash arrives at each agency and when it is returned after trading, the duration is the same. This implies that the total time involved in these activities is 60 minutes per trip, where two staff members are involved at an average labour cost of R37 each. Therefore the value of c_{312} is R74 per trip. These movements of cash occur twice a day according a fixed schedule.

If the values for c_{311} and c_{312} are substituted into Equation 4-3, it becomes:

$$C_{31}(Q) = 35 \frac{D}{Q_D} + 74 \frac{A}{Q_A} \dots \dots \dots (4-4)$$

Figure 4.3
Order policy followed at branch





4.3.3.2 The transportation cost element of the supply cost

The transportation cost consists of two elements. The first reflects the cost of delivery or removal by SBV to and from the branch. The second pertains to the supply of cash to the agencies. In the model proposed in Chapter 2, no distinction was made between these two elements. The cost of transportation was shown to be a step function, the distinction between the two curves emanating from the difference in transportation cost for normal and interim (or special) deliveries by SBV to the branch.

The cost of a normal delivery by SBV (c_{331}) is R500, whereas the cost of a interim delivery (c_{332}) is R1 000. For the period under review, the branch received only one interim delivery due to special circumstances. The interim delivery occurred on April, 29, and was a direct result of the branch having moved premises during the previous days. SBV visited the branch on 18 occasions during the review period of three months. Of these visits, 14 were for the purpose of delivering cash, whereas four visits were for the removal of cash. On one occasion delivery and removal of notes occurred simultaneously, on one occasion coin and notes were delivered on the same day and on one occasion notes were delivered and coin removed on the same day. When delivery and removal occur simultaneously (as for example in the case of a denomination switch), it does not affect the transportation cost (*i.e.* it remains R500 for the trip).

The timing of the deliveries has been a problem for the branch, since the delivery time on a particular day is only communicated to the branch 30 minutes before the delivery occurs. This is done for obvious security reasons. A contributing factor is that all banks experience the same peaks in their demand patterns, therefore SBV just has so much more to deliver when the demand peaks occur (for example at month end). The impact of the supply lead time will be investigated in greater detail in a subsequent chapter. Suffice it to say that the branch has taken a decision to order cash for the month end peak for the previous day, due to the uncertainty regarding the delivery time.



The values for c_{331} and c_{332} are substituted into Equations 2-9 and 2-10. Instead of using C_{33} to denote the transportation cost, C_{33B} is used to indicate transportation to and from the branch by SBV.

For a special delivery

$$C_{33B}(Q_i) = 1000 \frac{D}{Q_D} \dots \dots \dots (4-5)$$

For a normal delivery

$$C_{33B}(Q_i) = 500 \frac{D}{Q_D} \dots \dots \dots (4-6)$$

As stated above, the model does not provide for deliveries from the branch to the agencies. Obviously, if a branch has no agencies, this factor may be omitted. However, the branch under review does have two agencies and whereas visits from SBV are the exception rather than the rule, cash is moved to and from the agencies on a daily basis. This implies ten trips per week to each agency. If required a special trip may be requested on a Saturday to Agency A, but this is not provided for in the normal contract amount. Although the trip needs to be specially arranged, the cost remains the same as for a normal trip. The fixed amount of R6 053 for transportation of cash between the branch and the agencies is based on an average of 20 days on which trips are undertaken, in other words 40 trips per month to each agency or a total of 80 trips per month. Therefore the cost per trip is R76. A special trip to Agency A on a Saturday would cost the same.

Shortages at the agencies are not catered for. Should a customer arrive with a request for a particularly large withdrawal without prior arrangement, the customer is referred to the branch. The customer would then have to travel to



the branch which is located approximately five kilometres from Agency A and three kilometres from Agency B.

Equation 4-7 is used to determine the transportation cost between the branch and the agencies:

$$C_{33A}(Q_j) = 76 \frac{A}{Q_A} \dots\dots\dots (4-7)$$

where C_{33A} represents the transportation cost between the branch and the agencies.

The total transportation cost C_{33} will be equal to the sum of C_{33B} and C_{33A} .

4.3.3.3 The in-transit insurance cost element of the supply cost

The in-transit insurance cost element is not treated as a separate component of the supply cost. It is included in the transportation cost, C_{33} , which remains constant irrespective of the size of the order. This implies that a small order delivered during the same trip as a large order, subsidises the in-transit insurance of the large order. The value of C_{34} is 0 for this particular case and for all other South African retail banks that make use of the services of SBV. The same applies to the two carrier companies that are used to transport cash between the branch and the agencies. In-transit insurance is included in the amount charged per trip.

4.3.3.4 The total supply cost

The total monthly supply cost for the period April to June 1998 is summarised in Appendix F. As mentioned before, the branch follows a policy of avoiding special deliveries from SBV and limiting normal deliveries to a single occasion per week. The resulting supply cost is low in comparison to the total monthly storage cost over the same period calculated in Appendix E.



4.3.4 The total cost of cash holding

Appendix G summarises the total daily cost of cash holding at the branch and its two agencies for the period April to June 1998. The next step is to investigate the effect of changes to the above-mentioned policies on the total cost of holding cash with the aim of reducing the total daily cost of holding cash without compromising customer service and without running due risk of a shortage situation.

4.4 Conclusion

Chapter 4 investigated a case representative of the situation found at South African retail banks with the aim of illustrating how the cost parameters of holding cash may be estimated. Subsequently, the cost of the current order policy was determined for a period of three months. In Chapter 5 the demand patterns are investigated. Once this has been concluded, the effect of changes to the existing order policy will be investigated in subsequent chapters.