CHAPTER 7

A proposed decision support model for cash replenishment

7.1 Introduction

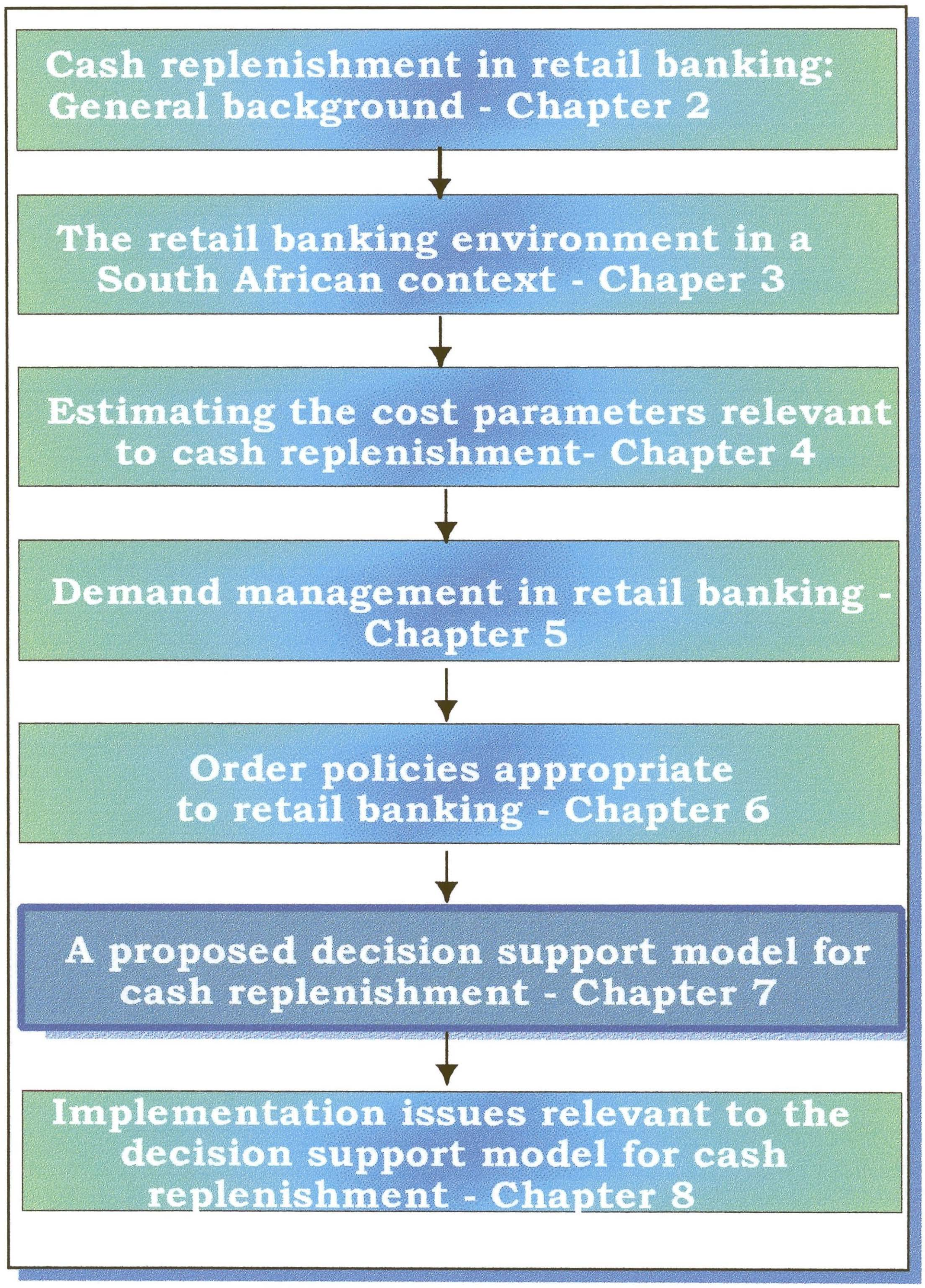
In Chapter 5 various demand management issues were discussed which were deemed to be relevant to the cash replenishment situation in retail banking. The most important conclusion arrived at in this chapter, was that the weights used by the branch in determining the scope of deposits and withdrawals may be refined to improve the estimates of the amounts. In Chapter 6, the implicit order policy adhered to by the branch was challenged. In this chapter it was shown that alternate order policies, which do not even consider the seasonality present in the deposit and withdrawal patterns, will reduce the total cost of holding inventory at the branch.

In Chapter 7, a decision support model is proposed which combines the forecasting methods investigated in Chapter 5 and the order policies suggested in Chapter 6. The conceptual model is subsequently evaluated using the real data patterns provided by the branch, in an attempt to show that a combination of the forecasting techniques and order policies will lead to an even greater cost reduction than that achieved in Chapter 6 without compromising the customer service level provided at the branch.

Figure 7.1 shows the relevance of this chapter with regard to the research project.

Figure 7.1

The structure of the report indicating the relevance of Chapter 7

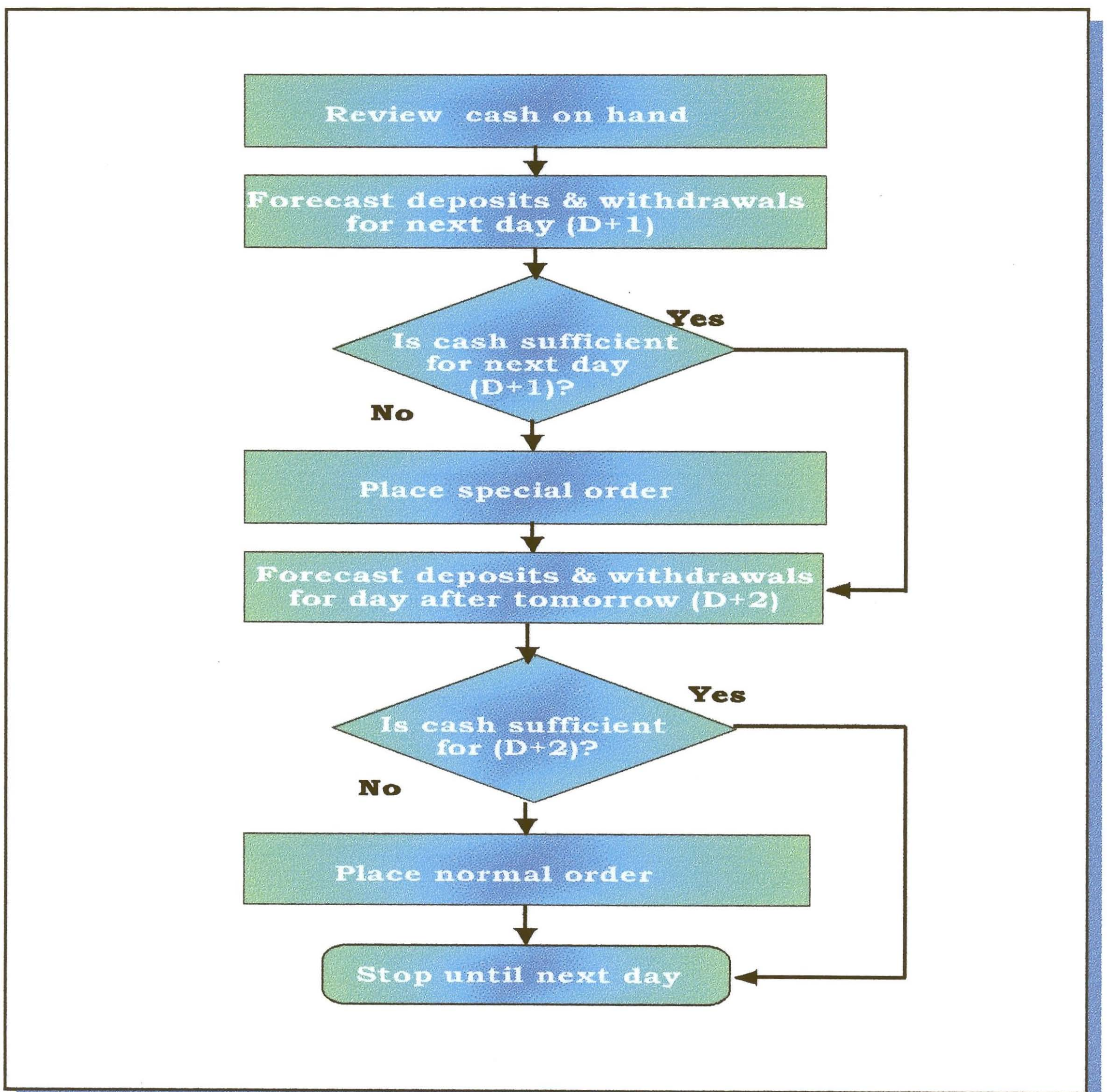


7.2 A decision support model for cash replenishment

Figure 7.2 shows a diagrammatic representation of the proposed decision support model for the branch which combines the order policy with a forecast based on seasonality.

Figure 7.2

A decision support model for cash replenishment at branch level



7.3 Application of the proposed decision support model

In Chapter 5, four different cycles were suggested as possibilities in forecasting deposit and withdrawal patterns. Various methods were applied and for each cycle a "best" method was suggested. In this paragraph, the assumption is made that the seasonality of deposit and withdrawal patterns correspond. Since three measures of forecast error were used in Chapter 5, and since these error measures do not necessarily confer with regard to the "best" method, all possibilities were explored. Table 7.1 provides a summary of the methods investigated for the four different cycles. The methods represented in the table are based on the results reported earlier in Chapter 5 in Tables 5.7 and 5.9. The full results of the use of the methods combined with the "best" order policy as determined in Chapter 6, are shown in Appendix P.

The suitability of each of the cycles, combined with the forecasting method and the order policy, is discussed in the following paragraphs. In each case the criteria for suitability reflect the avoidance of shortages as well as the cost involved. The benchmark for cost is the cost of the "best" order policy as determined in Chapter 6, *i.e.* an order quantity of R750 000, a special order size of R500 000, a safety stock level of R200 000 and a reorder point of R900 000. The cost of holding cash inventories in this instance was R2 466 per day.

However, as before, the reorder point is not fixed at the amount of R900 000, but varied from R300 000 to R1 000 000 to study the effect on the total cost of holding inventory. In addition, when necessary, the rule of simplicity with regard to use and understanding is used to select a preferred forecasting method.

Table 7.1

Combinations investigated assuming that the seasonality cycles of withdrawal and deposit patterns correspond

Seasonality	Withdrawal forecast method	Deposit forecast method	Result summary
6 days	Moving average with simple seasonal relatives	Moving average with simple seasonal relatives	Appendix P1-1
		Winter's method with regressed trend & simple seasonal relatives	Appendix P1-2
	Winter's method with regressed trend & simple seasonal relatives	Moving average with simple seasonal relatives	Appendix P1-3
		Winter's method with regressed trend & simple seasonal relatives	Appendix P1-4
24 days	FIT smoothing with default trend & simple seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix P2-1
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix P2-2
		Simple average with simple seasonal relatives	Appendix P2-3
	Simple average with simple seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix P2-4
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix P2-5
		Simple average with simple seasonal relatives	Appendix P2-6
	Simple average with moving seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix P2-7
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix P2-8
		Simple average with simple seasonal relatives	Appendix P2-9

Table 7.1 (Continued)
Combinations investigated assuming that the seasonality cycles of withdrawal and deposit patterns correspond

Seasonality	Withdrawal forecast method	Deposit forecast method	Result summary
26 days	Simple average with simple seasonal relatives	Simple average with simple seasonal relatives	Appendix P3-1
		Winter's method with regressed trend & simple seasonal relatives	Appendix P3-2
		Winter's method with regressed trend & moving seasonal relatives	Appendix P3-3
30 days	FIT smoothing with default trend & simple seasonal relatives	Simple exponential smoothing with simple seasonal relatives	Appendix P4-1
		Simple average with simple seasonal relatives	Appendix P4-2
		Winter's method with regressed trend & simple seasonal relatives	Appendix P4-3
	Simple average with simple seasonal relatives	Simple exponential smoothing with simple seasonal relatives	Appendix P4-4
		Simple average with simple seasonal relatives	Appendix P4-5
		Winter's method with regressed trend & simple seasonal relatives	Appendix P4-6

7.3.1 Seasonality based on a six day cycle

Two methods were considered to forecast withdrawal patterns if the seasonality is based on a six day cycle, *i.e.* a moving average combined with simple seasonal relatives (based on mean absolute percent error and mean absolute deviation) and Winter's method with a regressed trend and simple seasonal relatives (based on the root mean square error). The deposit patterns were forecast using the same two methods. The results are shown in Appendices P1-1, P1-2, P1-3 and P1-4.

From Appendices P1-1 and P1-2 the combination of withdrawals and deposits both forecast using moving averages and simple seasonal relatives and the combination of withdrawals forecast using moving averages and simple seasonal relatives and deposits forecast using Winter's method with a regressed trend and simple seasonal relatives, create situations where no shortages occur irrespective of the reorder point. In both cases the reorder point of R300 000 provides the lowest cost per day - in the first case R2 398 and in the second case R2 392. Both of these represent an improvement on the previous lowest cost per day of R2 466, achieved in Chapter 6.

The results of the combinations represented in Appendices P1-3 and P1-4 are disqualified based on the erratic nature in which shortages occur as the reorder point is varied from R300 000 to R1 000 000.

7.3.2 Seasonality based on a 24 day cycle

Appendix P2 summarises the results for the order policy explained before combined with a seasonal cycle based on 24 days. Based on the root mean square error, both withdrawals and deposits were forecast using a simple average combined with simple seasonal relatives. Using the mean absolute percent error, withdrawals were forecast using FIT smoothing with a default trend combined with simple seasonal relatives, whereas deposits were forecast using simple exponential smoothing combined with moving seasonal relatives. If the mean absolute deviation is used as a measure of forecast error, withdrawals were forecast using a simple average combined with moving seasonal relatives, whereas deposits were forecast using FIT smoothing with a regressed trend together with moving seasonal relatives.

In studying the results of these combinations, only two do not display erratic shortages patterns. In the first case withdrawals were forecast using FIT smoothing with a default trend combined with simple seasonal relatives, while deposits were also forecast using FIT smoothing, but a regressed trend is used in combination with moving seasonal relatives (results in Appendix P2-2). In the second case withdrawals were forecast using a simple average with moving seasonal relatives, while deposits were forecast using simple exponential smoothing with moving seasonal relatives (results in Appendix P2-9). In the first case, the suggested reorder point is R400 000 which results in a daily cost of R2 471, whereas the second case suggests a reorder point of R500 000 resulting in a daily cost of R2 470. None of these represent an improvement on the benchmark of R2 466 or an improvement on the daily cost achieved in paragraph 7.3.1.

7.3.3 Seasonality based on a 26 day cycle

When using a 26 day cycle, one forecasting method consistently provided the "best" results for withdrawals based on the three methods of forecast error used to evaluate the methods investigated, *i.e.* a simple average combined with simple seasonal relatives. The methods used to forecast the deposit patterns were a simple average with simple seasonal relatives (based on root mean square error), Winter's method with a regressed trend and moving seasonal relatives (based on mean absolute percent error) and Winter's method with a regressed trend and simple seasonal relatives (based on mean absolute deviation).

The three possible combinations all provide feasible alternatives having a daily cost lower than the benchmark cost of R2 466. The results are shown in Appendices P3-1, P3-2 and P3-3. The results of the 26 day cycle are however not as good as the results based on the six day cycle reported in paragraph 7.3.1.

7.3.4 Seasonality based on a 30 day cycle

Two methods were proposed for forecasting withdrawal patterns for a 30 day cycle, *i.e.* FIT smoothing using a default trend and simple seasonal relatives (based mean absolute percent error and mean absolute deviation) and a simple average with simple seasonal relatives (based on root mean square error). To forecast deposit patterns, three methods were suggested, *i.e.* a simple average with simple seasonal relatives (based on root mean square error), simple exponential smoothing combined with simple seasonal relatives (based on mean absolute percent error) and Winter's method with a regressed trend and simple seasonal relatives (based on mean absolute deviation).

The six possible combinations all provided daily costs improving on the benchmark cost of R2 466. Although some of the combinations did create shortages at lower reorder points, the shortage patterns were not erratic as shown for the 24 day cycle before. The results are shown in Appendices P4-1, P4-2, P4-3, P4-4, P4-5 and P4-6. The best results were obtained in Appendices P4-1 and P4-3. In both cases the withdrawals were forecast using FIT smoothing with a default trend and simple seasonal relatives, whereas the deposits were first forecast using simple exponential smoothing combined with simple seasonal relatives and, subsequently, using Winter's method with a regressed trend together with moving seasonal relatives. In both cases the reorder point was R300 000 and the daily cost was equal to R2 371. This not only substantially improves on the benchmark cost, but provides the "best" alternative achieved thus far.

7.3.5 Conclusion

Table 7.2 summarises the results of the investigation reported on in the preceding paragraphs.

The results show that under the assumption that deposits and withdrawals display the same seasonal pattern, the "best" approach based on lowest daily cost of holding cash inventory would be to use a 30 day cycle. The lowest cost alternative was achieved using a FIT smoothing forecasting technique with a default trend combined with simple seasonal relatives to forecast withdrawals. The deposits could be forecast using either simple exponential smoothing combined with simple seasonal relatives or Winter's method with a regressed trend with moving seasonal relatives. In both cases the daily cost is R2 371 compared to the current cost of R2 466 (determined in Chapter 6). Based on the criteria of simplicity and ease of use, exponential smoothing combined with simple seasonal relatives would be the preferred method for forecasting deposit patterns over a 30 day cycle.

The other notable result of combining the forecasting method with the order policy, is that the reorder point has dropped form R900 000 to R300 000 implying that the cash inventories held at the branch have reduced significantly leading to a reduced risk should a bank robbery occur.

7.4 An investigation into different cycles for withdrawals and deposits

In contrast to the assumption made before, where withdrawal and deposit patterns were assumed to have corresponding cyclical behaviour, this assumption is now revoked. The selection of the withdrawal and deposit forecasting method is merely based on the minimisation of the forecast error, irrespective of the cycle involved. In the case of deposit patterns, the three methods of forecast error were all minimised where deposits were assumed to have a 24 day cycle. Refer to Table 5.9 for confirmation of the results. However, in the case of the withdrawal patterns, the minimisation of forecast error does not indicate a "most suitable" cycle, since the three measures of forecast error each indicate a different period to be appropriate. The root mean square error indicated a cycle of 26 days, the mean absolute percent error pointed to a 24 day cycle, whereas the mean absolute deviation was minimised over a 30 day cycle. The various combinations of the "best" methods are summarised in Table 7.3.

Table 7.3

Combinations of forecasting methods based on minimisation of forecast error

Withdrawal seasonality	Withdrawal forecast method	Deposit forecast method (using a 24 day cycle)	Result summary
24 days (based on the minimisation of the mean absolute percent error)	FIT smoothing with default trend & simple seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix P2-1
		Simple average with simple seasonal relatives	Appendix P2-3
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix P2-2
26 days (based on the minimisation of the root mean square error)	Simple average with simple seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix Q1-1
		Simple average with simple seasonal relatives	Appendix Q1-2
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix Q1-3
30 days (based on the minimisation of the mean absolute deviation)	FIT smoothing with default trend & simple seasonal relatives	Simple exponential smoothing with moving seasonal relatives	Appendix Q2-1
		Simple average with simple seasonal relatives	Appendix Q2-2
		FIT smoothing with regressed trend & moving seasonal relatives	Appendix Q2-3

However, if the results from Appendices P2, Q1 and Q2 are studied, none of the combinations provide a solution which reduces the daily cost further than the figure of R2 371 achieved in the previous paragraph. The assumption therefore has to be made that at this particular branch, the deposit and withdrawal patterns correspond with regard to cyclical behaviour.

7.5 The proposed model compared to the reality

In conclusion, the proposed method for replenishment of cash may be compared to the reality at the branch during the three month period under review. The comparison is shown in Table 7.4. Figure 7.3 compares the daily amount of cash on hand as it really occurred and what would have been the case had the proposed method been used during the three month period under review.

Table 7.4

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

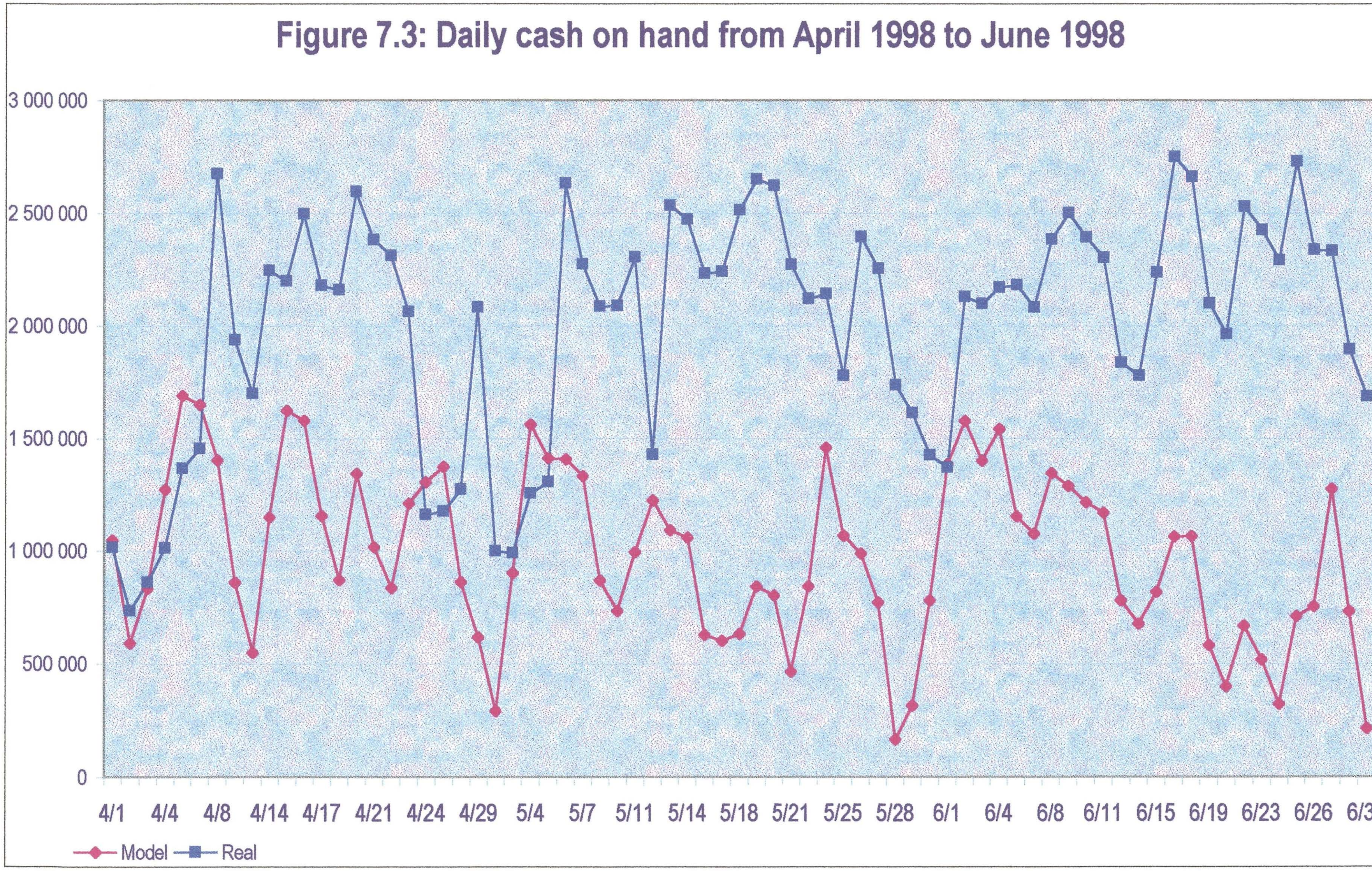


Figure 7.3: Daily cash on hand from April 1998 to June 1998
3 000 000
2 500 000
2 000 000
1 500 000
1 000 000
500 000
0
4/1
4/4
4/8
4/14
4/17
4/21
4/24
4/29
5/4
5/7
5/11
5/14
5/18
5/21
5/25
5/28
6/1
6/4
6/8
6/11
6/15
6/19
6/23
6/26
6/30
Model
Real

7.6 Conclusion

From the comparison in Table 7.4, the advantages of using the proposed method rather than the existing method are obvious. The improvement achieved represents a 13 per cent bottom line cost reduction which equates to R358 per day. If it assumed that a year comprises 300 trading days, the annual saving at the branch is equal to R107 400. Should similar savings be achieved at all branches, the impact will be even more significant. At the time that the research was carried out, 75 branches of a similar size existed within the portfolio of this particular retail bank. If the saving achieved at this branch is extrapolated, it implies a potential annual saving of over R8 000 000. Obviously, the scope of such savings at branches that exhibit other deposit and withdrawal patterns will have to be determined. As stated earlier in the research, the cost calculations were based on an assumption regarding shortage cost, *i.e.* that the shortage cost is equal to ten times the storage cost.

The final chapter of this report discusses issues regarding the implementation of a decision support model of this nature.