A decision support model for the cash replenishment process in South African retail banking

Susanna Aletta Adendorff

submitted in partial fulfillment

of the requirements for the degree

Philosophiae Doctor in the Faculty of Engineering,

University of Pretoria, PRETORIA

September 1999

Dedicated with love to

my father, Kris

(the father of Industrial Engineering in South Africa),

my mother, Riekie

and my sons, Herman and Kristian.

ABSTRACT

Title: A decision support model for the cash replenishment process in South African retail banking

Author: Susanna Aletta Adendorff

Supervisor: Prof P S Kruger

Department: Department of Industrial and Systems Engineering, University of Pretoria

Degree: *Philosophiae Doctor* in the Faculty of Engineering

The objective of the research was to establish a scientifically-based decision-making procedure for determining the amount of cash to be held at a cash point at any time without compromising the customer service level or incurring undue cost. To reach the objective, the problem was divided into the following subproblems:

- To determine the cost parameters describing the nature of the problem of cash provision in South Africa.
- To investigate the characteristics unique to South African retail banking.
- To determine the nature of the demand distribution for a cash point.
- To develop a forecasting method appropriate for retail banking, although it was clearly stated that the methods used were specific to the branch studied.
- To investigate the existing order policies used by retail banks, as well as alternative order policies, with the aim of improving the cash replenishment process.

As a result of the investigation a generic decision model was developed which

may be used to improve the process at branch level for retail banks in South Africa. Some suggestions were also made regarding the implementation and maintenance of the model.

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, deposit patterns and the withdrawal patterns at the automated teller machines (ATM's) 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, 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.

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 to successfully use the decision support model.

A comparison was drawn between the existing approach followed at the branch (which is mainly experience-based and largely of a random nature) to the proposed method. It was shown that the daily cost of carrying cash inventory

could be reduced by 13 per cent per day. This represented a daily bottom line cost reduction of R358. At the time that the research was carried out, this retail bank had 75 similar branches. Should the saving at this representative branch be extrapolated, it shows a potential saving of R8 000 000 per year at this category of branch. It was further shown that the average cash inventory at this branch could be reduced by 52 per cent using the proposed method.

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 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.

During the period under review, the branch relocated to a complex across the street from its previous location in a busy shopping mall. This had a direct impact on the ATM withdrawal patterns at the two ATM's located at the branch. In addition, soon after the research was carried out, a number of other branches of the same retail bank were consolidated into this one particular branch. This would impact on the validity of the branch specific factors determined as part of the research.

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 enhance share-holder value. In the changing environment confronting retail banks, enhanced share-holder value is of the utmost importance to increase competitiveness and long-term survival.

Key terms

Decision support model

Cash replenishment

Cash replenishment cost parameters

Retail banking

Characteristics of retail banking in South Africa

Forecasting techniques

Order policies for cash replenishment

Deposit and withdrawal patterns

Implementation of decision support model

Industrial engineering in services

SAMEVATTING

Titel: 'n Besluitsteunmodel vir die kontantaanvullings-proses in Suid-Afrikaanse handelsbanke

Outeur: Susanna Aletta Adendorff

Promotor: Prof P S Kruger

Departement: Departement Bedryfs- en Sisteemingenieurswese
Universiteit van Pretoria

Graad: *Philosophiae Doctor* in die Fakulteit Ingenieurswese

Die doel van die navorsing was om 'n wetenskaplik gefundeerde besluit-prosedure daar te stel om te bepaal hoeveel kontant op enige tydstip by 'n kontantvoorsieningspunt gehou moet word, sonder om die diensvlak aan kliënte te kompromitteer en sonder om onnodige koste aan te gaan. Om hierdie doelwit te bereik, is die probleem in die volgende subprobleme verdeel:

- Om die kosteparameters te bepaal wat die aard van die probleem van kontantvoorsiening in Suid-Afrika beskryf.
- Om die unieke eienskappe van die Suid-Afrikaanse handelsbankwese te ondersoek.
- Om die verdeling wat die vraag na kontant by 'n voorsieningspunt beskryf te bepaal.
- Om 'n vooruitskattingsmetode te ontwikkel wat geskik is vir handels-bankwese, alhoewel dit uitdruklik gestel is dat die metodes wat ondersoek is, spesifiek was aan die tak wat bestudeer is.
- Om die bestaande bestelbeleid wat deur handelsbanke gevolg word te ondersoek, asook om na alternatiewe te kyk met die doel om die kontant-aanvullingsproses te verbeter.

Na aanleiding van die navorsing is 'n generiese besluitmodel ontwikkel, wat aangewend kan word om die proses op takvlak in Suid-Afrikaanse handelsbanke te verbeter. Enkele voorstelle is ook gemaak aangaande die implementering en instandhouding van die model.

Om die kontantaanvullingsprobleem te ondersoek, is die samewerking van een van die toonaangewende handelsbanke in Suid-Afrika verkry. 'n Tipiese tak is geselekteer. Die totale onttrekkings-, deposito- en geoutomatiseerde teller-masjienonttrekkingspatrone oor 'n periode van drie maande gedurende 1998 is ondersoek. Die kosteparameters relevant tot die kontantaanvullingsproses is gekwantifiseer. Die benadering wat gevolg is, was gebaseer op die klassieke voorraadteorie waar die totale koste van voorraadhouding uit drie koste-kategorieë bestaan, naamlik, houkoste, bestelkoste en tekortekoste. Aangesien banke versuim om die tekortekoste te kwantifiseer, was dit nodig om aannames te maak aangaande die tekortekoste.

Die volgende stap was om die koste van die bestaande bestelbeleid wat deur die tak gevolg word te bepaal. Hierdie syfer is as 'n baken gebruik tydens die ondersoek na alternatiewe tot die bestelbeleid. Die ondersoek het gelei tot alternatiewe bestelbeleide wat die daaglikse koste van die hou van voorraad betekenisvol verminder asook die gemiddelde hoeveelheid kontant wat deur die tak gehou word, verlaag.

Daar is ook aangetoon dat die tak oorweging moet skenk aan die gebruik van 'n geskikte vooruitskattingsmetode, aangesien die kombinasie van 'n gepaste vooruitskattingsmetode en 'n geskikte bestelbeleid tot verdere veminderings in die voorraadhoukoste gelei het.

Ten slotte het die verslag 'n implemeteringsplan voorgehou wat op takvlak gevolg kan word, wat uitgewys het dat bepaalde veranderings wat betref die inligting-stelsel nodig is. Verder is opleidingsbehoeftes geïdentifiseer wat die operasionele bestuurder van die tak in 'n posisie sou stel om die besluitsteunmodel suksesvol te kan aanwend.

'n Vergelyking is getref tussen die bestaande benadering wat gevolg word by die tak (wat hoofsaaklik op ondervinding gebaseer en grootliks op toevalswyse uitgevoer word) en die voorgestelde metode. Daar is aangetoon dat die daaglikse koste van voorraadhouding met 13 persent per dag verminder kan word. Dit het 'n daaglikse besparing van R358 bewerkstellig. Ten tye van die studie het hierdie handelsbank 75 soortgelyke takke gehad. Sou die besparing by hierdie verteenwoordigende tak geëkstrapoleer word, sou dit 'n potensiële besparing van meer as R8 000 000 per jaar impliseer by hierdie kategorie takke. Daar is verder getoon dat die gemiddelde kontantvoorraad by hierdie tak met 52 persent verminder kon word deur die voorgestelde metode te gebruik.

Die studie was beperk tot 'n ondersoek by een spesifieke tak van 'n toon-aangewende Suid-Afrikaanse handelsbank. Die syfers wat gebruik is om die kontantbewegings by die tak te beskryf was van 'n uiters sensitiewe aard en betreklik moeilik om te bekom vanweë die wyse waarop transaksies gerapporteer word. Alhoewel 'n spesifieke geval ondersoek is, is 'n doelgerigte poging aangewend om aan te dui hoe die metode ook in die generiese situasie toepassing vind.

Tydens die navorsingsperiode het die tak hervestig na 'n gebou oorkant die straat van waar dit tevore in 'n besige winkelsentrun geleë was. Dit het 'n direkte impak gehad op die ontrekkings by die twee geoutomatiseerderde tellermasjiene (OTM's) wat by die tak geleë is. Bykomend, pas nadat die navorsing voltooi is, het konsolidasie van verskeie takke binne dieselfde bankgroep plaasgevind. Dit sou 'n impak hê op die geldigheid van die takspesifieke faktore wat tydens die studie bepaal is.

Die studie het die toepaslikheid van die beginsels van bedryfsingenieurswese in 'n diensomgewing bewys, waar die bykomende waarde van die hou van die optimum kontanthoeveelheid soos benodig, 'n direkte impak op die winsgewend-heid van die bank sal hê, en sodoende die waarde van die aandeelhouersbelang sou verhoog. In die hedendaagse, veranderende omgewing wat handelsbanke konfronteer, is verhoogde waarde van aandeelhouersbelang krities vir verbeterde mededingendheid en langtermynoorlewing.

Sleutelterme

Besluitsteunmodel

Kontantaanvulling

Kontantaanvulling kosteparameters

Handelsbankwese

Eienskappe van handelsbankwese in Suid-Afrika

Vooruitskattingstegnieke

Bestelbeleide vir kontantaanvulling

Deposito- en onttrekkingspatrone

Inplementering van besluitsteunmodel

Bedryfsingenieurswese in dienste

Preface

The application of industrial engineering in a service environment has always been of great interest to me. I have always been of the opinion that much scope exists for the expansion of the role of industrial engineers specifically in the service industries in South Africa. As a result of this belief and interest, I decided to undertake the research in the field of South African retail banking. My conviction was confirmed by the results of the research project and I trust that the results and conclusions of the research will stimulate further work in this field.

On completing a work such as this, it is appropriate to give thanks to the people who were directly involved or merely provided the crucial support to make the research possible. I am indebted to the following people:

- The decision makers at the retail bank who were prepared to give me access to the required information;
- the staff at the branch who were extremely cooperative and had enormous patience in answering all my questions;
- my supervisor, Prof Paul Kruger in the Department of Industrial and Systems Engineering at the University of Pretoria; and
- my parents and my sons, Herman and Kristian, who supported me throughout the endeavour.

I hereby declare that this is my own work.

Signed in Pretoria on 19 September 1999.

S A ADENDORFF

Table of contents

Chapter 2

The complexity of cash replenishment in retail banking

Chapter 3

The retail banking environment in a South African context

Chapter 4

Estimating the cost parameters relevant to cash replenishment

Chapter 5

Demand management in retail banking

Chapter 6

Order policies appropriate to retail banking

Chapter 7

A proposed decision support model for cash replenishment

Chapter 8

Implementation issues relevant to the decision support model for cash replenishment

Chapter 9

Conclusion

Appendices

List of figures

Page

Chapter 1

The scope of the research

Chapter 2

The complexity of cash replenishment in retail banking

Chapter 3

The retail banking environment in a South African context

Chapter 4

Estimating the cost parameters relevant to cash replenishment

Chapter 5

The impact of demand management issues in retail banking

Chapter 6

Order policies appropriate to retail banking

Chapter 7

A proposed decision support model for cash replenishment

Chapter 8

Implementation issues relevant to cash replenishment in retail banking

List of tables

Page

Chapter 4

Estimating the cash replenishment cost parameters

Chapter 5

Demand management in retail banking

Chapter 6

Order policies appropriate in retail banking

Chapter 7

A proposed decision support model for cash replenishment

Acronyms and terminology

ABA	American Bankers' Association
ABSA	Amalgamated Banks of South Africa
ATM	Automated teller machine
Banking Council	The Banking Council - South Africa
CIMC	Crime Information Management Centre
COSAB	Council of South African Banks
FIT	Forecast including a trend
MAD	Mean absolute deviation
MAPE	Mean absolute percent error
MSR	Moving seasonal relatives
SD	Standard deviation
SSR	Simple seasonal relatives
Reserve Bank	South African Reserve Bank
RSFE	Running sum of forecast errors
RSME	Root mean square error
SAPS	South African Police Service
SARB	South African Reserve Bank
South Africa	Republic of South Africa
TS	Tracking signal
UK	United Kingdom
USA	United States of America

NOTE: *Throughout this document, the decimal point is used to denote the decimal separator. This is done to comply with standard practice in the banking environment.*

Definition of variables

Variable	Definition	Unit
C	Total cost of cash handling	Rand/period
C_1	Storage cost	Rand/period
c_{11}	Cash float cost	Rand/unit period
c_{12}	Insurance cost	Rand/unit period
c_{13}	Labour cost element of storage	Rand/unit period
C_{13}	Labour cost involved in storage	Rand/period
C_2	Shortage cost	Rand/period
C_3	Supply cost	Rand/period
C_{31}	Order cost element	Rand/period
c_{31}	Unit replenishment cost	Rand/order
c_{311}	Internal order and processing cost for SBV visit	Rand/order
c_{312}	Internal order and processing cost for agency visit	Rand/order
C_{32}	Total cash processing cost	Rand/period
C_{33}	Transportation cost element	Rand/period
c_{331}	Normal unit transportation cost	Rand/order
c_{332}	Interim unit transportation cost	Rand/order
C_{34}	In-transit insurance cost	Rand/period
c_{34}	In-transit insurance cost	Rand/unit period
Q_O	Demand for current scheduling period	Units
$\sum Q_i$	Amount held in current scheduling period	Units
Q_D	Amount ordered from cash centre per delivery	Units
D	Total demand in planning period	Units
Q_A	Amount ordered/returned from agencies per delivery	Units
A	Total demand at agencies during planning period	Units
Q	Order quantity	Rand
SQ	Special order size	Rand
SS	Safety stock level	Rand
I_0	Initial inventory	Rand
UL	Upper limit	Rand
RA	Return amount	Rand
ROP	Reorder point	Rand