TOWARDS A SYSTEMIC UNDERSTANDING

OF THE DYNAMIC INTEREST INCOME

PERFORMANCE OF A RETAIL BANK

By

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Abstract

The strategic management of financial services firms has become an increasingly complex task over the last three decades. The banking industry, until the end of the 1970's, was heavily protected and characterised as a staid and stable industry in the age of '3-6-3' banking (borrow at 3%, lend at 6%, be on the golf course by 3 p.m.). This age came to an abrupt end and banks were forced to become competitive and fast [Matten: 1996]. Today, the banking industry is characterised by volatile markets, increasing consumerism, globalisation and competition, the rapid introduction of new technology, a changing regulatory environment and an increasingly inter-coupled business environment. Under conditions of increasing complexity and interconnectedness, it has become increasingly difficult to manage a modern financial services firm by intuition alone.

The aim of this dissertation is to demonstrate how a system dynamics simulation model can expedite learning, insight and foresight for a typical retail bank involved in lending and deposit-taking activities in a retail banking market.

The model represents the interest income generating system of a typical retail bank embedded in its environment. The exogenous environmental inputs can be initialised with a wide range of different characteristics; a stable interest rate environment versus a volatile environment, a mature market with low loans growth versus a fast growing market, and so on. Similarly the characteristics of the retail bank may be initialised with a wide range of characteristics; a start-up bank versus an established bank with a large loan and/or deposit book, aggressive versus conservative credit policies, etc.

In particular, we develop a dynamic hypothesis of the complex structure of the interest income generating system of a retail bank. This hypothesis is translated into a quantitative system dynamics simulation model that serves to provide an experimental tool for testing strategic responses of a typical bank under different environmental scenarios enabling us to infer how performance arises. The model demonstrates how performance arises ex-ante from the dynamic structure of the bank's resource system.

The experimental results provides a dynamic view on the performance characteristics of the income generating system of a retail bank described in the language of the Dynamic Resource Systems View of Warren and Morecroft [Warren: 2000].
✓ Firstly, the results show the scale of the resources developed; the size of the loans book, the number non-performing loans, the size of the depositor book book, and the consequent financial performance at any cross-sectional view in time.
✓ Secondly, the experimental results indicate at what rate the resources have developed; the speed at which the advances book has developed, the rate with which the depositor book is generated under a particular set of exogenous circumstances and endogenous policies.
✓ Thirdly, the results show that the observed performance of a number of similar banks can be described by a single, generic systemic feedback structure. Performance differences arise due to different resource endowments and decision policies of

decision agents with different dominant logics about how they should structure their business.

✓ Fourthly, the results show that the time evolution of financial performance of the interest income generating system is path dependent, that is, the time path of performance is constrained by its current resource endowments, policies and capabilities.

The central thesis of this dissertation is that the dynamic behaviour of interest income is a result of an endogenous systemic structure in response to external exogenous factors such as interest rate movements. It is our contention that the complex interrelationships between issues such as capital management, interest rate management, liquidity management, cost management, strategic objectives, etc, justifies the use of a more complex systemic and dynamic framework for analysis that may produce new insights into the behaviour and management of the interest income system for a typical retail bank. The purpose of this research is to demonstrate how the dynamic behaviour of interest income generation of a typical retail bank arises as much from the interaction of decision agents and tangible and intangible resource flows within the bank's system as from any exogenous inputs into the system.

The model developed here is a highly aggregate model of limited scope encompassing the traditional core issues facing a typical retail bank and sheds some light on the issues addressed by the model. Although being of limited scope, the model is deemed to be sufficiently comprehensive to demonstrate how the dynamics arise. The work presented here is not fully complete, it represents a plausible hypothesis of system under study but has not been sufficiently validated to be considered scientifically complete. Much further work is required. However, this dissertation represents work that has been undertaken to date in an attempt to understand the system under study from a systemic perspective.

Further extensions may be undertaken to provide insight into some of the current issues facing the modern retail bank executive. Understanding the dynamic structure of a retail bank sheds some light on the potential responses available to improve performance.

The contribution of this research lies in the systematic and systemic abstraction of the interest income generating structure of a typical retail bank, the development of a quantitative model thereof and the insights obtained from this. The model developed may be considered to be a generic model applicable to any bank with a similar structure but with different objectives, parameter values, resource levels, policy parameters and exogenous inputs and provides different performance time paths with the same structure. The insights about solutions are specific and time dependent. This provides an insight that traditional static models do not provide by identifying specific solutions applicable at specific time frames and valid for specific durations thus coupling a time dimension to all solutions.

Declaration

I, Peter Leonardes Lach, declare that this dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

Acknowledgements

Dedicated to

my wife Giuliana (companionship)

and my sons

Grant (curiosity) and Jason (energy).

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Chapter 1

Introduction

1.1. The Roots of the Banking Industry

Retail banking has its roots dating back many centuries where banking began with goldsmiths who developed the practice of storing gold and valuables for individuals. This practice was essentially one of storage of goods on behalf of the owner. Depositors left their gold at the goldsmiths, received a receipt as proof of deposit and were issued their gold deposit on presentation of their receipt [Samuelson & Nordhaus: 1985]. As this practice developed, it become common practice for the goldsmiths to pool all the gold receipts and to re-issue gold to customers from the common pool of gold.

The goldsmiths soon noticed that they continually held reserves of gold and whilst they held a large pool of gold, the gold would not be withdrawn all together. The result is that for daily requirements, only a small percentage of the gold (approximately 1%) would be required for payment. Capitalising on the situation, goldsmiths soon invested the reserve holdings in interest bearing assets enabling the goldsmiths to earn additional income. The result was that the amount of deposits owing to customers was far greater than the amount of gold held in reserve at the goldsmith. Today, similar principles apply. Banks take in deposits on which they pay interest, create assets through lending of money on which they earn interest, and in the case where asset creation exceeds deposit taking, obtain funds in the money market to make up the shortfall on deposits.

1.2. Modern Financial Deposit-taking Institutions

Modern financial institutions evolved as financial intermediaries, taking deposits or funds from one group and re-lending them to another. Deposit taking is enabled through various financial instruments such as savings accounts, negotiable certificates of deposits, etc. Similarly, asset creation (lending) is enabled through financial products such as mortgage bonds, personal loans, cheque overdrafts, etc.

In recent years, banking institutions have come under pressure to shift their emphasis from generating interest income to generating non-interest income such as fee income charged for services rendered. This is the consequence of an increasingly competitive loans environment characterised by shrinking margins as well as an increasingly volatile interest rate environment due to higher levels of connectedness between economies of the world. During the late 1990's the "Asian crisis" sparked by a run on the economies of the "emerging tigers" in the far east resulted in severe increases in interest rates in South Africa, despite a reasonably stable and positive outlook on the domestic economic front. During late 1998, the prime interest rate reached extreme levels of 25,5% with a consequent detrimental effect on the economic front, and on the interest income levels of banks.

Banks saw their net interest margins narrow dramatically, non-performing advances as a percentage of performing advances rise dramatically, growth in new advances decline dramatically and bad debts surge to unprecedented levels. Banks with the largest exposure to loans showed the severest impact. These phenomena are well understood and managed through an asset and liability management process as well as a credit management process. However, it is our contention that the interconnectedness of the internal bank structures forges the many actions and forces affecting one another to produce the total consequences of what we observe in bank performance. Taking this viewpoint, a dynamic hypothesis can be developed about the interest income generation system as a feedback-loop structure with a consequent dynamic behaviour. Whilst steady state behaviour of the system is observed most of the time, the transient behaviour and response of the system can generally only be observed during times of instability in the financial markets such as which was witnessed during the late 1990's. This provides a unique opportunity to study the system from a resource-based view and feedback-loop perspective, develop and test a dynamic hypothesis and draw inferences about the future behaviour of such a system under various dynamic conditions.

1.3. The Central Thesis

This leads us on to the central thesis; it is our contention that the dynamic behaviour of income generation of a typical retail bank arises as much from the exogenous inputs and "shocks" to the system as from the interactions of decision agents and tangible and intangible resource flows within a typical retail bank. Thus, the dynamic interest income behaviour is dependent on an internal, systemic structure. Given two banks that have identical structures, a difference in dynamic interest income performance outcomes must be due to differing initial conditions. Alternatively, given identical initial conditions and similar structures, difference in interest income performance can be attributed to the way decision are made governing the flow of resources internal to the bank, i.e. due to differing decision policies and dominant logics of the decision agents. It is argued that all banks have similar structures but that differences in observed performance are due to different decision policies and different levels of resource endowments.

1.4. The Aims of this Research

The aim of this dissertation is to develop a resource-based systemic and dynamic view of the interest income generation structure of a typical retail bank that will allow us to test our dynamic hypothesis about the causes of observed transient behaviour and explain the dynamic behaviour from a complex feedback perspective. It is our view that it is insufficient to explain the behaviour by describing issues such as capital management, interest rate management, liquidity management, cost management, strategic objectives, etc in isolation and that sufficient synergies exist between these variables to justify the use of a more complex systemic and dynamic framework for analysis.

1.5. Research Strategy

The strategy adopted for this research is to develop and analyse a model of a retail bank. This approach thus uses a formal mathematical model as the primary study tool. Since we are interested in understanding the time path of important variables and the dynamics of the time paths, and since accounting accuracy or forecasting is not a major focus but rather the impact of policy on the trends in time-path evolution, it is suggestive of a modelling strategy that can be classified as dynamic and deterministic. The dynamic deterministic case offers a basic and transparent representation of the key resources and their evolution and is of sufficient sophistication to afford insight into the impact of policies and exogenous variables on the time paths of important business variables.

1.6. Modelling Perspective

The modelling perspective taken is that of the dynamic resource systems view, a combination of the resource-based view of the firm and the system dynamics modelling methodology [Morecroft: 2000]. This perspective affords the development of a continuous, deterministic and dynamic model that relates the resource and feedback structure of the business to the longer-term dynamic evolution of the business performance. This model constitutes a dynamic hypothesis of the system under study, the output of which must be verified and validated against the observed behaviour of the actual system. The business relationships are embodied in the form of a mathematical, behavioural system dynamics model, supported by data provided from existing data sources (where available), documentary evidence and interviews of knowledgeable banking persons.

1.7. The Object of Study

The development of the hypothesised structure is based on the actual performance experienced by a Retail Banking division of a large multi-functional South African Financial Services Group over the period April 1995 to March 2000. The division served, mainly, the middle market segment offering lending products and deposit-taking facilities and was a key player in the mortgage loans market. The company has since been fundamentally re-structured. The Retail Banking division of this company is the object of our study, being representative of a typical retail bank. We will refer to the object of our study, hereinafter, as "the bank".

The bank was characterised by a large advances (loans) book of which the dominant portion consisted of mortgage loans. The size of the advances book (loans on hand) continuously exceeded the value of the deposits book resulting in a shortage of deposits funding to cover the loans created. This situation is typical for South African retail banks as opposed to many banks in wealthier countries, such as the United Kingdom, where deposit taking often exceeds asset creation. Consequently, the bank relied heavily on obtaining the necessary funding in the money markets leading to a sizeable funding book. During the late 1990's the large interest-rate sensitive book was exposed to the volatile interest rate movements with massive increases in funding rates resulting in prime lending rates soaring to an all time high of 25,5%. Consequently, the bad debt situation rose significantly as consumers defaulted on their loans. The rate of new loan creation declined severely and deposit taking reduced significantly. The Prime interest

rate declined slowly to reach 15,5% by October 1999, but bad debt remained stubbornly high. The year-end financial results for the 1998/1999 financial years reflected a poor trading year. Total income for the division had declined, relative to the previous years, after a number of years of steady growth and the bad debt situation had worsened significantly with prospects appearing to be poor.

The financial results were attributed as a direct consequence of the volatile interest rate environment and the negative consequences thereof such as a decline in new loans and deposits and rising bad debt. The movement in funding rates provided a cyclical behaviour from a steady state to an all time high and reducing to a lower level again. From a systemic perspective, it is argued that the financial results are a response of the underlying system to the volatile behaviour of the interest rates and are symptomatic of a deeper underlying structure. A different structure would result in a different performance given the same volatile interest rate environment. The Retail Banking division of the South African Financial Services Group is used to develop and validate the systems hypothesis. Thereafter, the hypothesised structure is generalised for a typical retail bank and inferences are drawn from the behaviour of the generalised structure.

1.8. The Structure of this Dissertation

To set the context for this dissertation, Chapter 1 (this chapter) provides a broad overview of the aims, central thesis, objectives and research strategy adopted for this research.

Chapter 2. abstracts the problem, bounds the modelling effort, provides reference modes of observed behaviour and develops a preliminary conceptualisation of the links between key variables that forms the basis for the detailed model of the dynamic hypothesis.

Chapter 3 develops the formal dynamic hypothesis of the underlying structure that generates the observed reference modes of behaviour in the form of a deterministic resource-based feedback model. This chapter provides an overview of the model sectors, conceptualisation of the business structure, formulation of equations, feedback loop structure and justification of the model structure.

Chapter 4 provides an exposition of the validation testing undertaken such as by replicating the observed modes of behaviour and other validation tests.

Chapter 5 develops the simulation experiments on the hypothesised structure to gain insight into the dynamic response of the structure. Further experiments are undertaken to infer behaviour under various potential conditions.

Chapter 6 discusses the insights gained, conclusions reached, advantages and shortcomings of the model, future research directions and the contributions made by this research.

Chapter 2

Problem Framing and System Conceptualisation

2.1. Introduction.

The key challenge of this research is to identify the underlying structure of systemic relationships that is the root generator of the dynamics of financial performance. The starting point is the identification of the global objective of the study followed by the development of a global goals-means network to identify relevant variables and resource accumulations. Thereafter reference modes of behaviour for the identified variables are analysed, i.e. graphical time bound descriptions of the actual behaviour of the system. This is followed by the development of an initial hypothesised feedback structure.

2.2. The Time Horizon for the Study

The period 1995 to 2000 provides a particularly good trading environment in which to study the dynamic interest income earnings performance of retail banks. The volatile interest rate environment during late 1998, in particular, provide an unique opportunity to obtain a deeper understanding of the dynamic response of the systemic feedback structure of the interest income generating system of a bank. The time horizon of 1 April 1995 to 30 March 2000, a five-year time period, has been selected because this period was characterised by a relatively stable interest rate environment during the initial half of the period and an extremely volatile interest rate environment during the latter half of the period. The stable period provides a basis for calibrating the model under stable conditions and the latter half provides insight into the dynamic response of the bank under extreme volatile environmental conditions.

2.3. Global Objectives and the Goals-Means Network

In order to provide initial focus and structure to the research, the net income after tax of a bank was selected as the global objective and primary measure of performance for this research. The entire modelling effort is based around this measurement.

Figure 2.1 decomposes the primary objective into a global goals-means network [Ritchie-Dunham & Rabbino: 2001]. This network decomposes the global objective into lower level means of attaining the higher-level goals. The lower level means goals identify the variables that influence the attainment of the global goal and provides a means to identify the resources required to attain the higher global goals. The means goals centre around the resources that create the value to attain the global goal. The variables that are resources are depicted by variables encapsulated in "boxes". Only the global objective has a target description i.e. maximise net income after tax. No target descriptions are given for the lower levels since the objective is to identify the variables that drive the means to attain the global objective.

The global goals-means network serves two purposes: provides a logical framework to identify the "means" variables and to identify the variables that are considered as key resource accumulations.

Figure 2.1

Global goals-means network
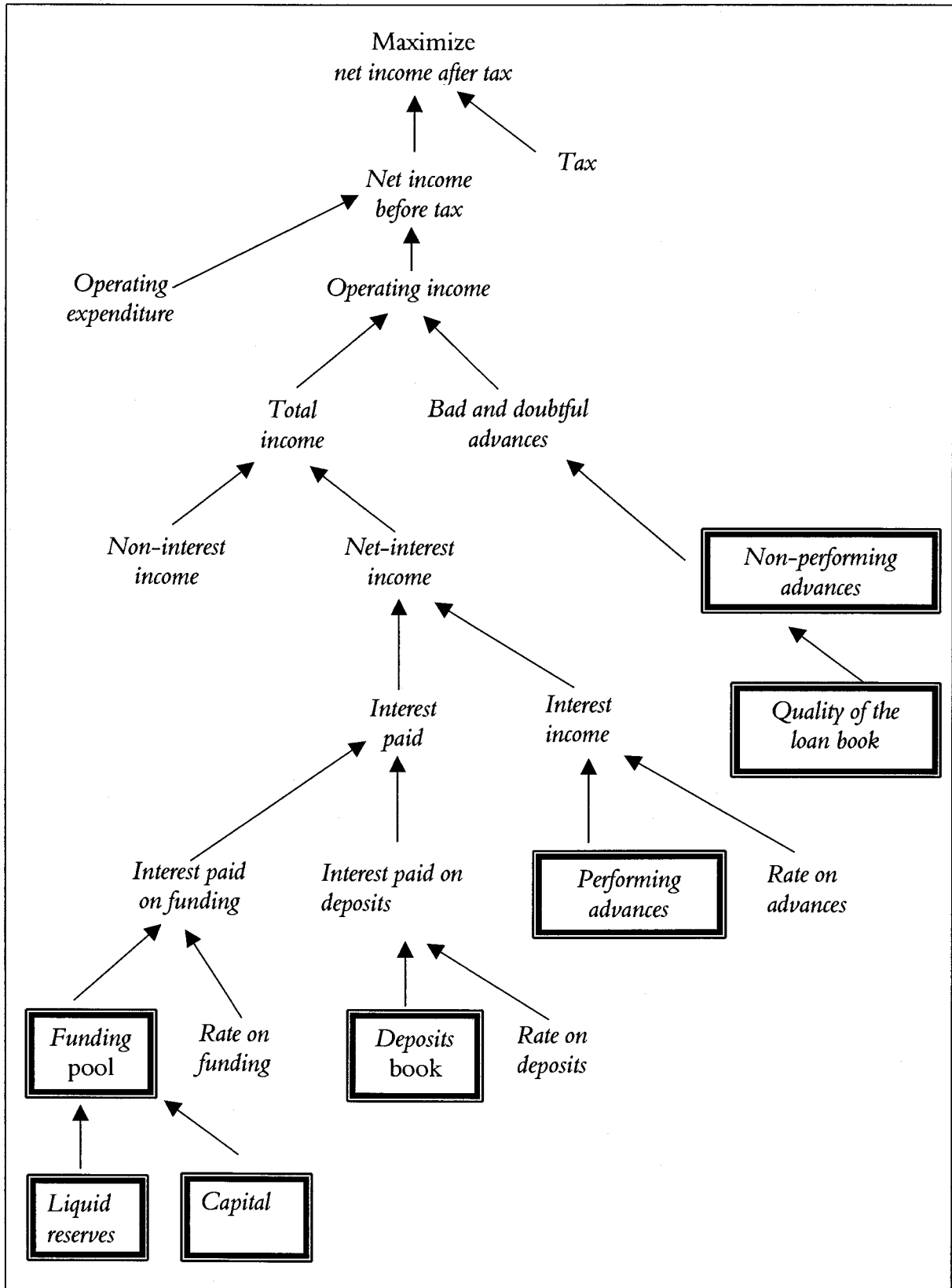
A convention used throughout the dissertation is the use of full descriptive names for all variables. For example, we will refer to *performing advances* and not an acronym such as *PA*. All variables will be shown in italics.

The network can be explained as follows; the goal of maximising *net income after tax* is achieved by means of the *net income before tax* and the *tax* paid. Those two elements are the variables that determine how *net income after tax* is attained. A similar approach applies to the remainder of the tree.

Non-performing advances, performing advances, funding, deposits, liquid reserves, capital and *quality of the loan book* are all considered key resources. The identification of these variables as key resources will be explained in detail in Chapter 3 where the resource-based view of the firm will be discussed.

The network can be extended further. For example, *performing advances* may be expanded to include the number of physical outlets (branches) in the country (a means to attain the advances), the number of salespersons, etc. For the purposes of this research, the boundary of the model extends only as far as shown in Figure 2.1 since the variables within the boundary are considered sufficient to meet the objectives of this study.

Figure 2.1 represents a linear, open-loop set of relationships that typifies the way many businesses represent and model the financial aspects of their businesses. This is typically modelled on a spreadsheet. This dissertation attempts to show how different conclusions can be reached using a systemic framework to measure and model the same financial variables.

Having completed the global goals-means network, the next phase of the research focuses on obtaining historical time graphs showing the performance of the main variables. This serves to give insight into how the system variables behaved over time and gives some direction to the search for underlying systemic feedback structure.

2.4.   Reference Modes of Observed Behaviour

The dynamic nature of the problem can be best understood if the variables of concern are plotted over time, focussing attention on the behaviour of the variables that are symptomatic of a deeper underlying structure [Forrester: 1961]. Figures 2.2 to Figure 2.18 illustrate the graphs of key variables for the bank over the five-year period from 1 April 1995 to 30 March 2000. More important than obtaining a precise value for the variable at any particular point in time is to obtain the patterns over time, that is, trends, periods of increases and decreases, peaks and valleys, phase relationships between variables and so on. Some of these graphs shown below represent annualised results as reported in the financial statements and therefore, these graphs do not reveal the full extent of the underlying dynamics i.e. the shorter term dynamics (monthly movements). The points of data measurement are represented by point values on the graphs, shown as solid symbols (squares, triangles or diamond shapes) joined by a solid line tracing between the points over the time horizon. Despite the lack of monthly movement data for much of the data, this provides a reference point of departure for establishing the dynamic hypothesis of the underlying structure.

2.4.1. Prime Interest Rate

The dynamics of the bank under study revealed a strong correlation to the volatile interest rate conditions during 1998. During this period the prime interest rate rose to an unprecedented high of 25,5% followed by a sharp fall to 15,5% by November 1999. The rate on advances for the bank is a function of the prime interest rate.

Figure 2.2

Prime interest rate
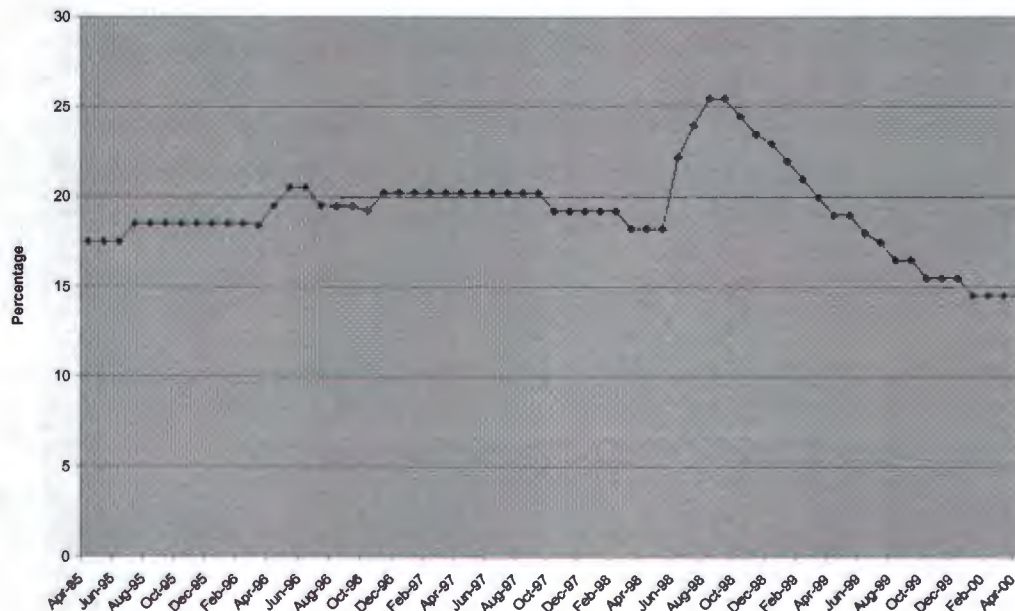
The rise in prime rate is underpinned by the rise in funding costs. The funding rate represents the interest rate charged by the treasury to the business unit on the amount of funding used by the business unit. The treasury obtains the funding in the money

markets from various sources and the final rate charged to the business unit represents the rate on the composite funding pool established by the treasury department. This rate reflects the average cost of obtaining and managing the funds.

Figure 2.3

Funding rate
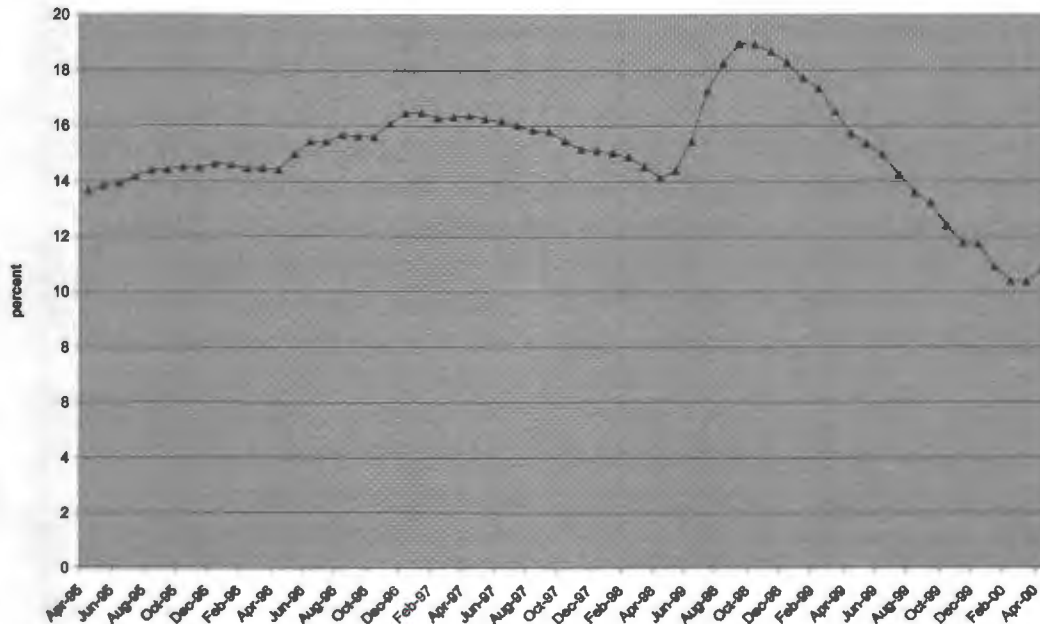
2.4.2. Advances (loans)
During this period of interest rate upheaval, net loans and advances continued to grow showing a moderate decline in growth rate between 1998 and 1999 and a severe decline in growth rate thereafter reflecting pressure on consumers to reduce exposure to debt.

Figure 2.4

Net loans and advances Rand (m)

Net loans & advances
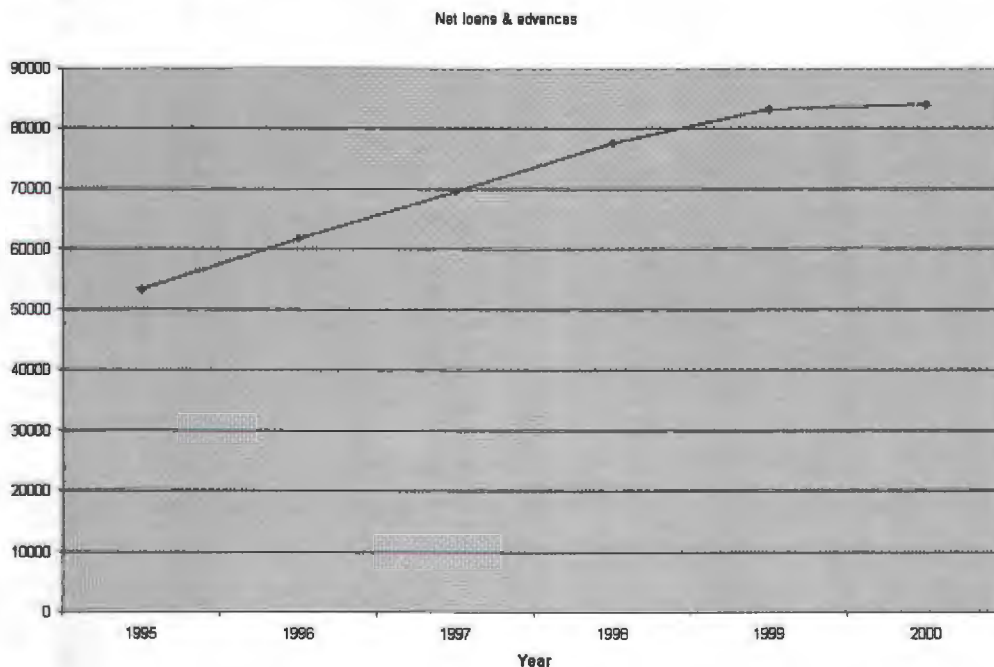
2.4.3. Deposits

The second half of the period was also characterised by a severe decline in rate of deposits as over leveraged depositors faced a financial liquidity crisis.

── **Figure 2.5**

Total deposits   Rand (m)
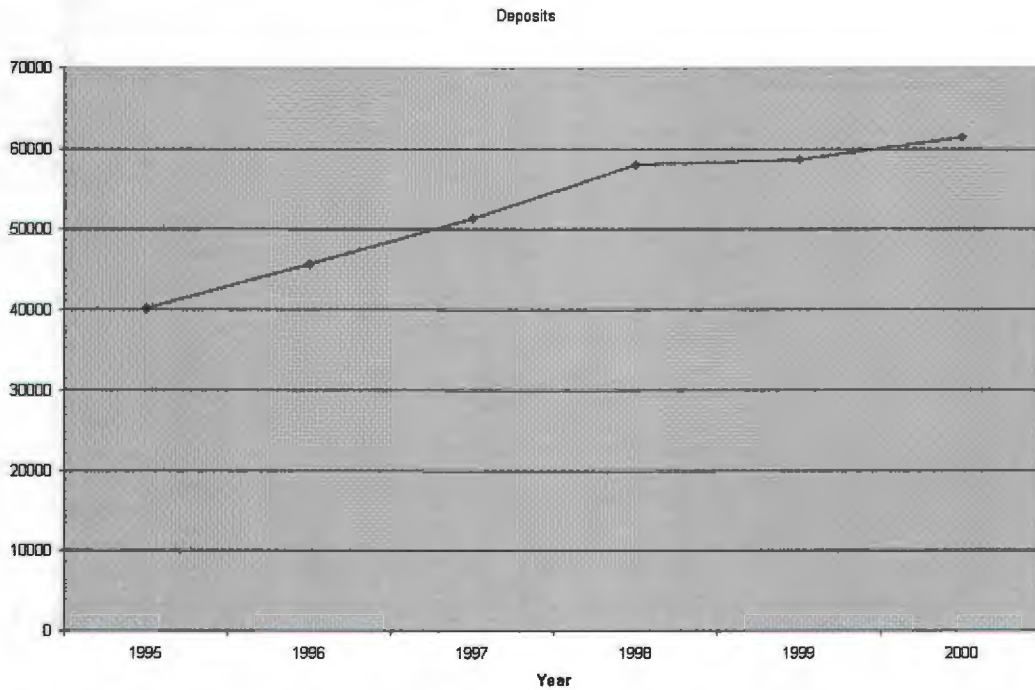
Deposits

2.4.4. Funding

Funding, the funds obtained by treasury to cover the shortfall of deposits over advances increased significantly over the period 1998 to 2000.

── **Figure 2.6**

Funding (Rand Bn)

Funding
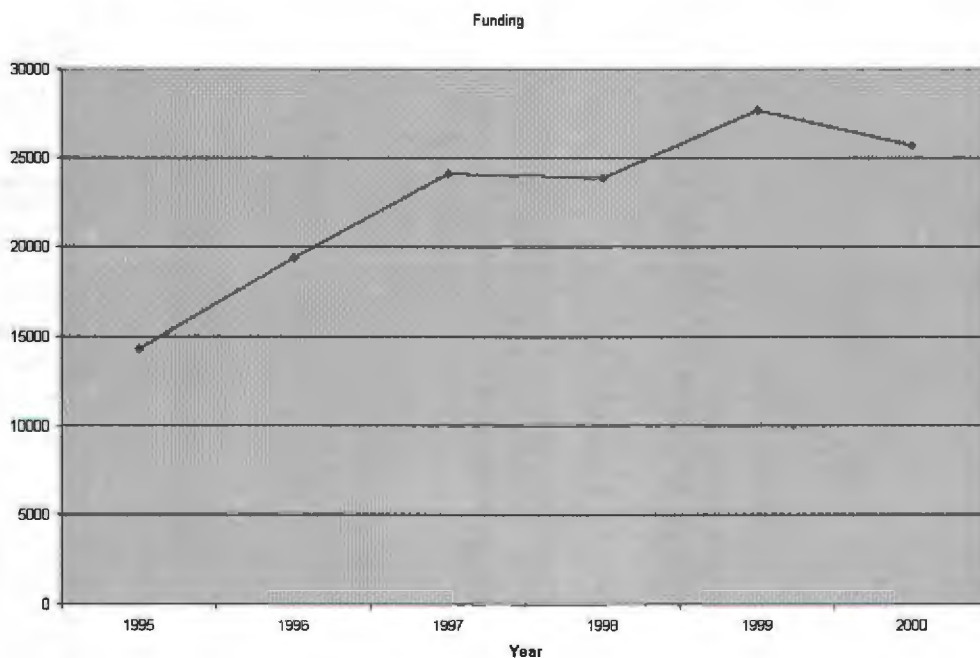
2.4.5. Net Interest Margins

Net interest margins (NIM) shows a decline over the initial time period under review, affected by the volatile interest rate period before resuming its downward path. The downward trend is representative of a difficult competitive environment.

Figure 2.7

Net interest margins (percent)

Net interest margins
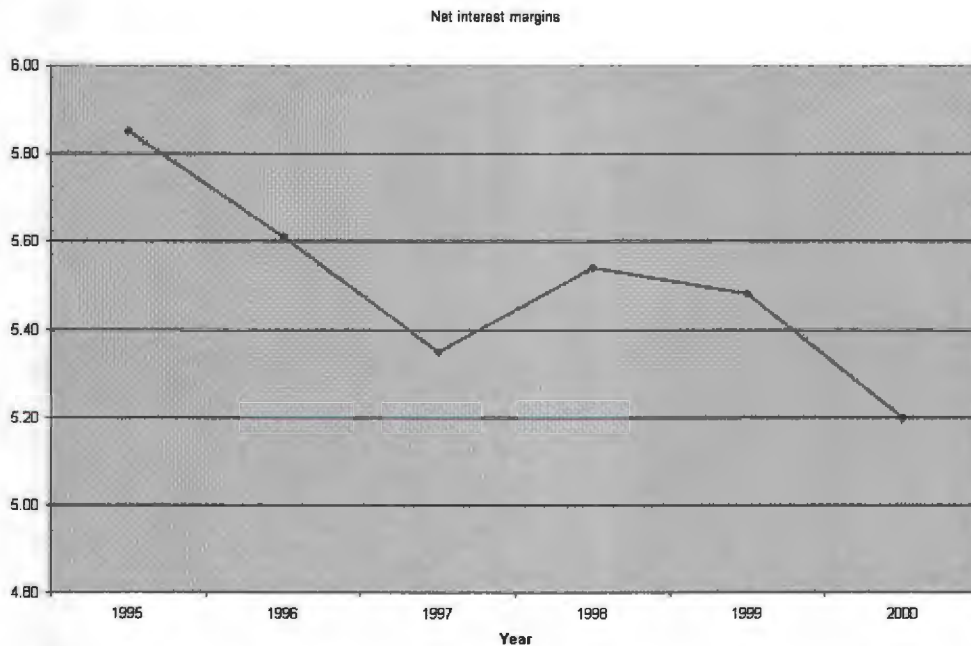
2.4.6. Interest Received, Interest Paid and Net Interest Received.

Figure 2.8 shows the monthly values of the Prime interest rate, the basis for calculating the interest received, and the funding rate, the basis for the interest paid. Net interest received for the bank is a result of the difference between the interest received and interest paid, that is, the gap between the two curves of Figure 2.8 determines the net interest received. What can clearly be seen is that when interest rates rise, net interest received increase (the gap increases) and when interest rates fall, net interest received declines (the gap reduces).

Net interest received increases when interest rates rise, because of the differences in timing of interest rate increases for interest received and interest paid. Interest received rises before interest paid rises and the difference between the two increases during periods of interest rate rises. Similarly, during periods of interest rate declines, the difference between interest received and interest paid narrows leading to a decline in net interest received during these periods. This phenomenon is a function of the characteristics of the advances, deposits and funding book. The advances book re-prices almost immediately as Prime interest rate changes whereas the deposits book and

funding book exhibit a delay before re-pricing. This delay is one of the key structural characteristics that creates the dynamic for the net interest received.

A bank that has a funding book and deposit book that re-prices with a far shorter delay would see an entirely different net interest received dynamic. During an interest rate upswing, the gap between interest received and interest paid would narrow leading to reduced net interest income and during an interest rate downswing, the gap would increase leading to an increase in net interest received. Thus, the structure of the advances, deposits and funding resources determines the net interest received. In addition, certain systemic feedback loops influence the funding resource, adding further systemic impacts on the net interest received. The impact of these feedback loops are usually not considered using conventional linear analytical techniques. The characteristics of the feedback loops are considered in section 2.8 of this chapter and the impact of the feedback loops are discussed in detail in Chapter 5, section 5.3. This dynamic is at the heart of the interest income generating system of a bank and is the main focus of this dissertation.

Figure 2.8

Interest received, interest paid and net interest received
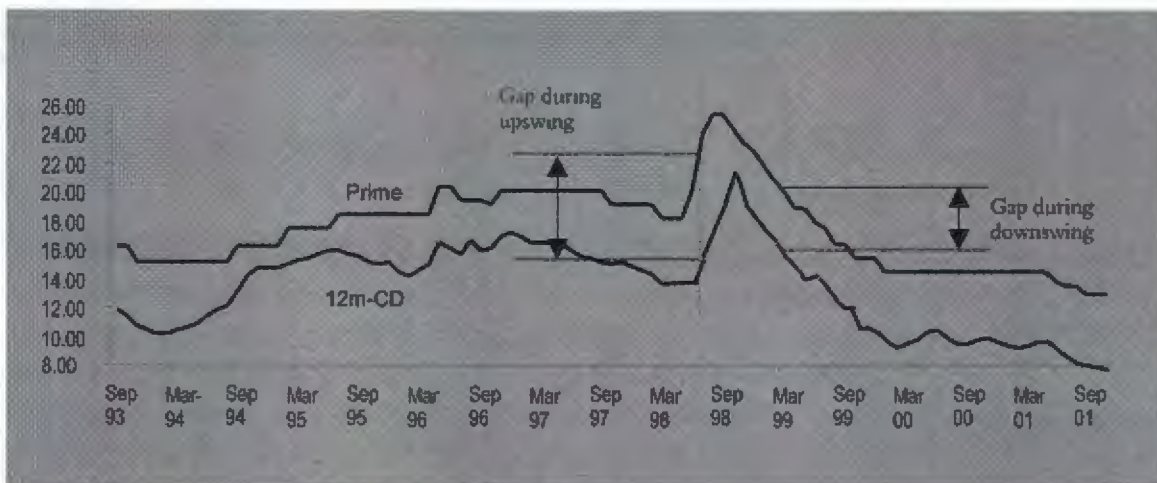
2.4.7. Net Income After Tax & Net Income Before Tax

The net income after tax displays the financial growth experienced by the bank between 1995 and 1998 and the severe decline in between 1998 and 1999 with a slow recovery thereafter. Figure 2.10 shows the corresponding net income before tax over the same period.

Net income after tax   Rand (m)

Figure 2.9

NIAT

Figure 2.10

Net income before tax

NIBT
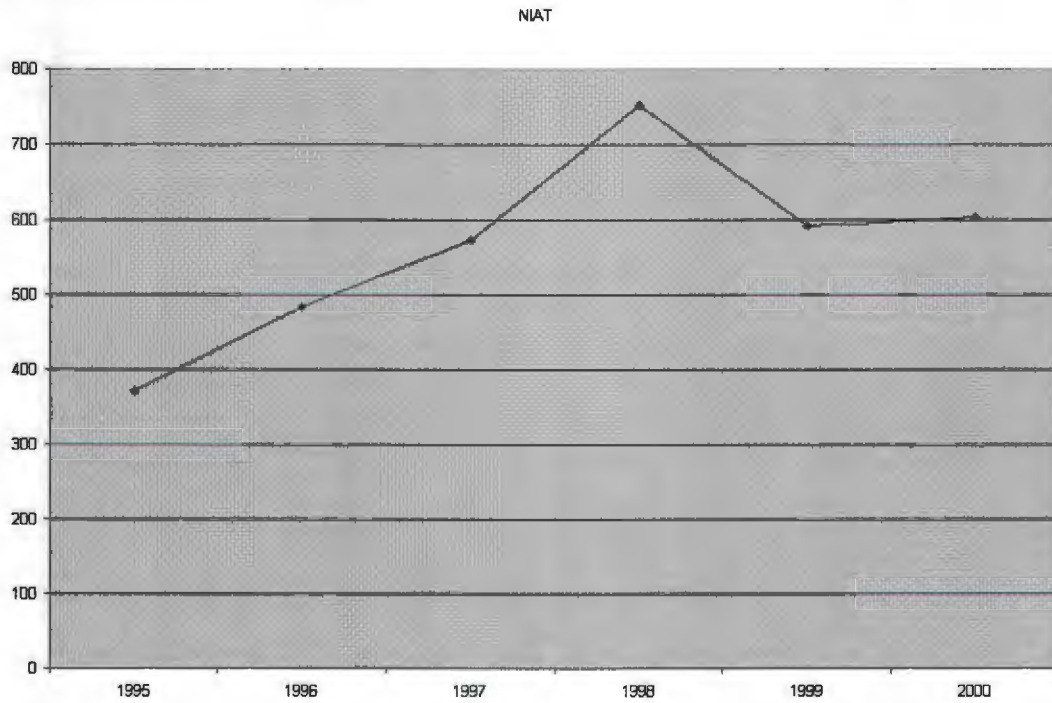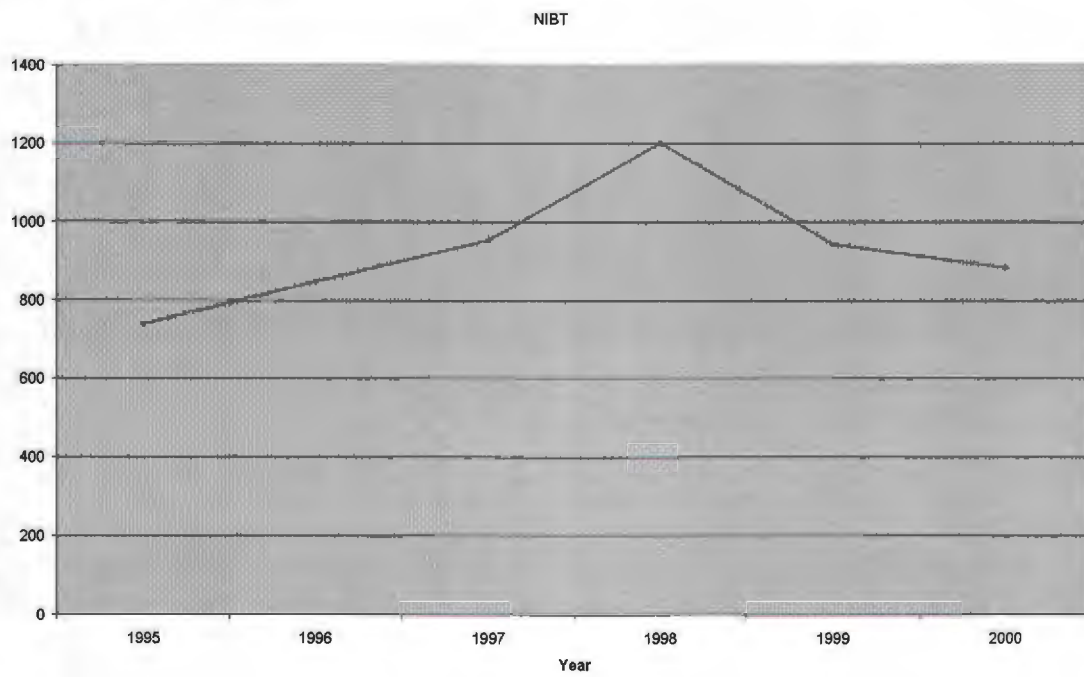
2.4.8. Operating Income
After 1998 a significant reduction in the growth rate in operating income can be seen.

Figure 2.11

Operating Income   Rand(m)
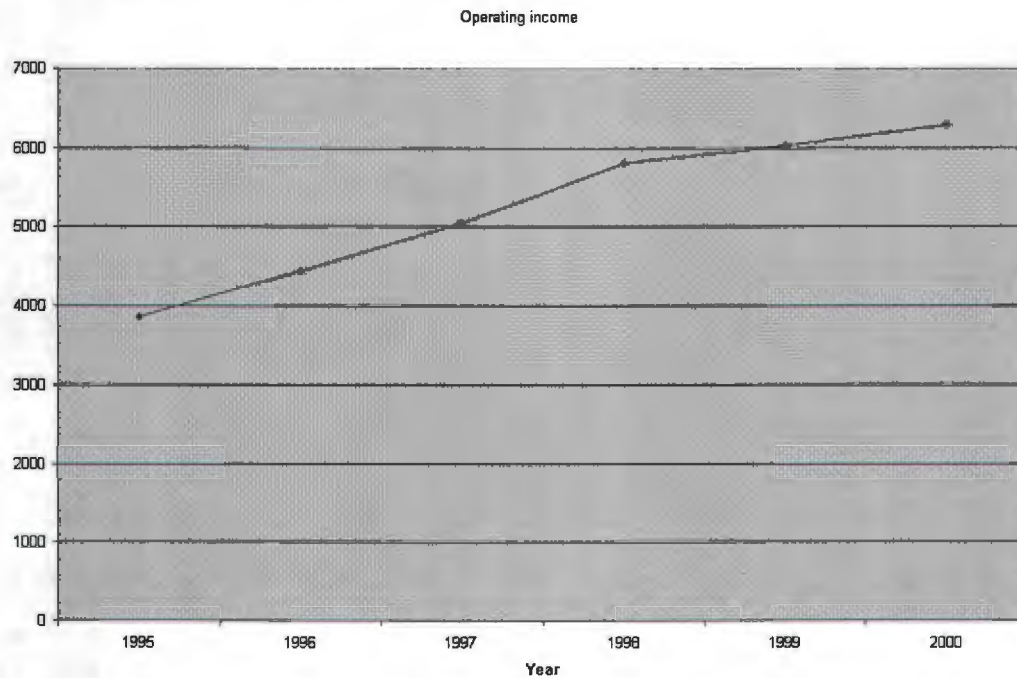
Operating income

2.4.9. Operating Expenditure
Operating expenditure continued to show strong growth over the corresponding period.

Figure 2.12

Operating expenditure   Rand(m)

Operating Expenditure

2.10
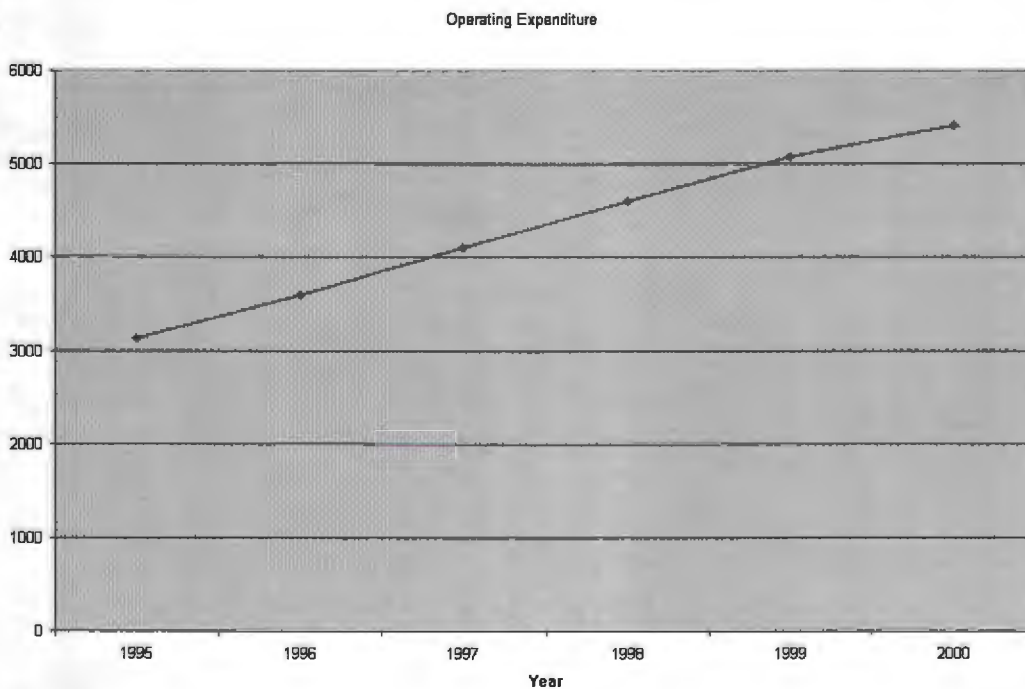
2.4.10. Total Income
Total income showed a strong decline between 1999 and 2000.

Total Income

Total income
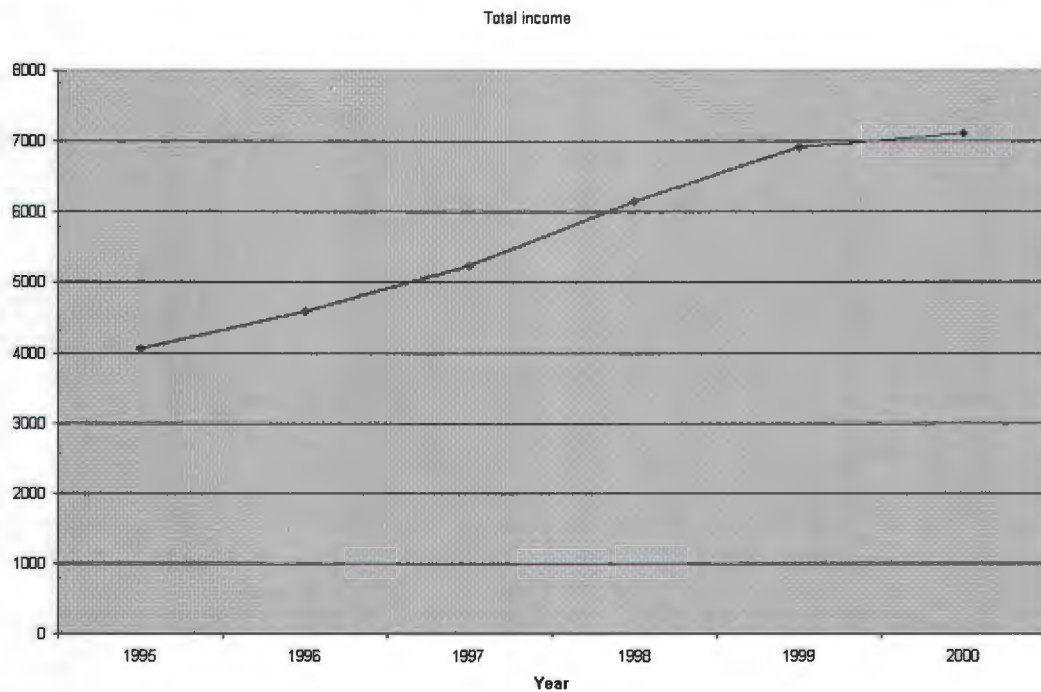
2.4.11. Bad Debt Provisioning
Bad debt provisioning over the time period under review continued to climb with a particularly severe surge in provisioning during 1999. This not only reflects the impact of severely high rates of interest but also reflects the quality of the retail advances underwritten by the bank.

Provision for bad and doubtful advances   Rand(m)

Bad & doubtful advances

2.11
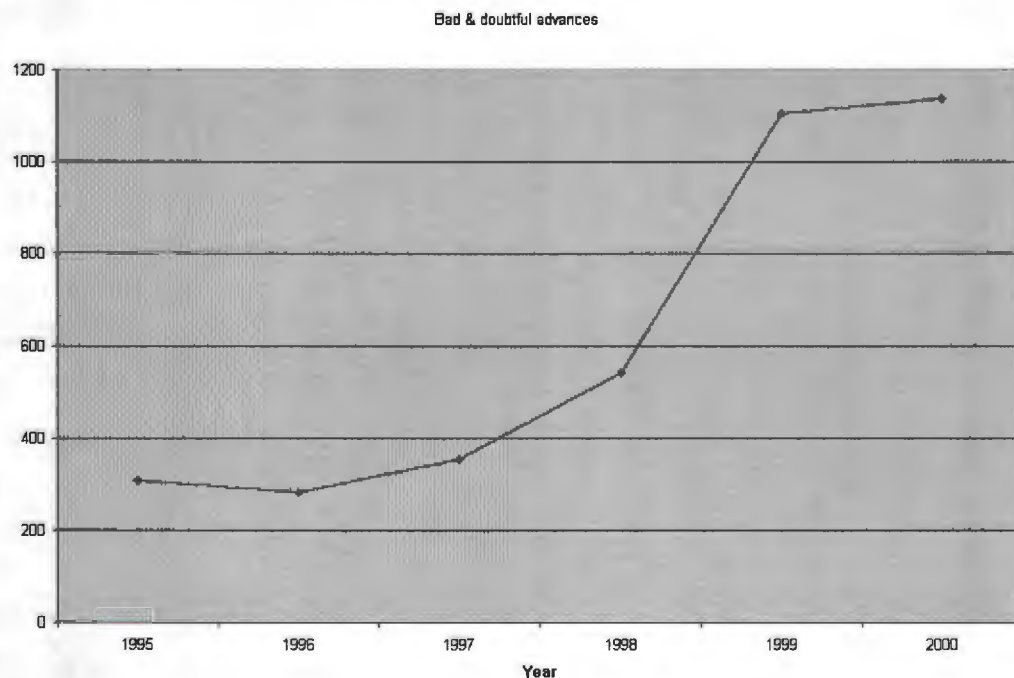
2.4.12. Net Interest Income

The net interest income continued to grow over the period under review but was severely contained as reported in the 2000 financial year results. The decline was the consequence of the sluggish growth in advances, narrower margins and reduced interest received on the high level of non-performing advances.

Figure 2.15

Net interest income (Rand Bn)

Net interest income
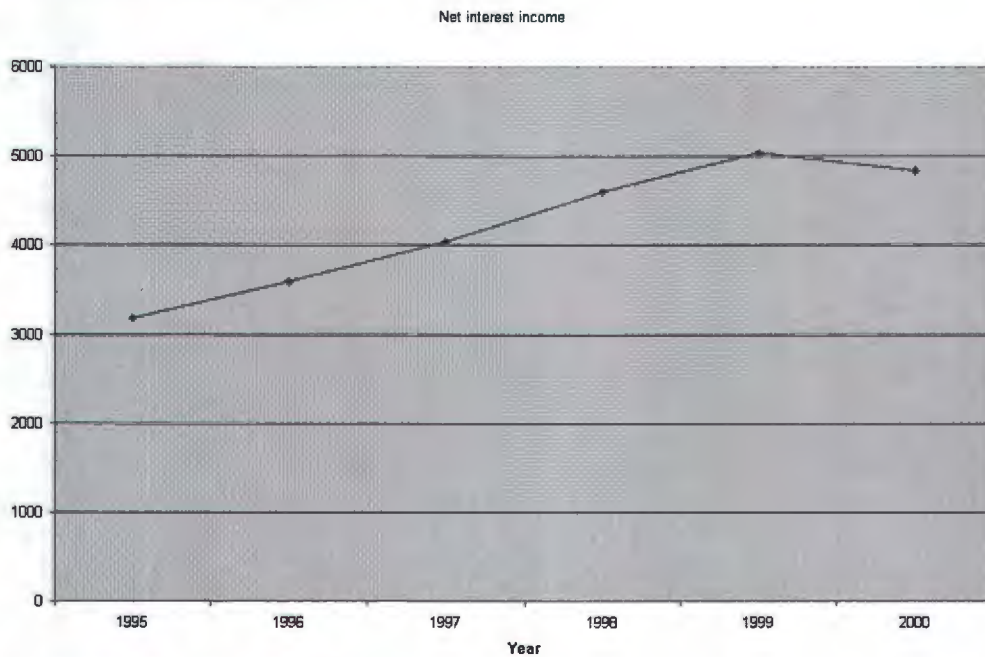
2.4.13. Non-interest Income

Non-interest income continued to grow unabated. Non-interest income is derived from non-interest bearing activities such as fee income.

Figure 2.16

Non-interest income (Rand Bn)

Non-interest income
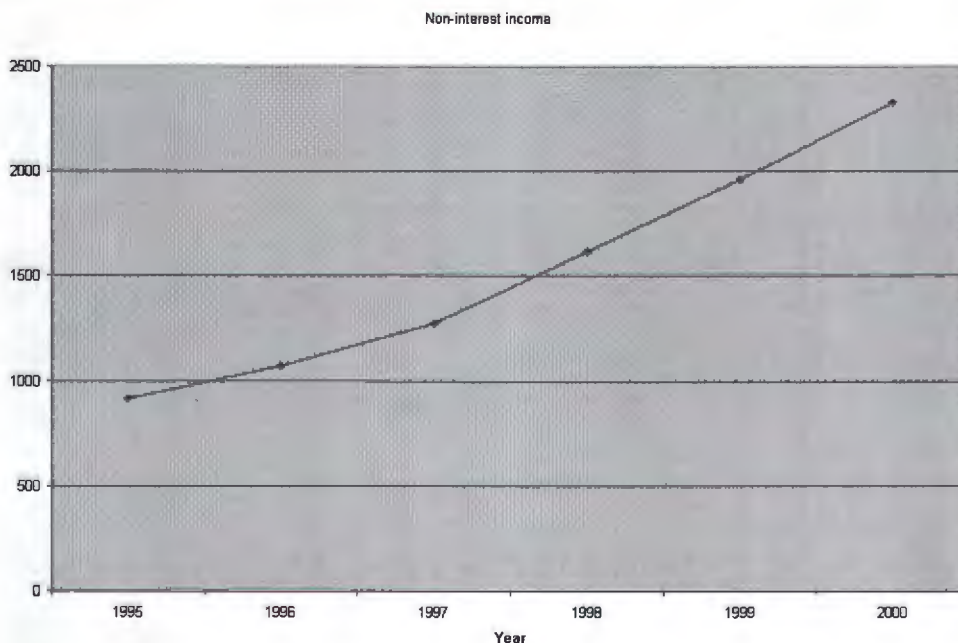
2.4.14. Cost-to-income Ratio

In the face of declining lending margins coupled with sluggish advances growth after the 1998 interest rate volatility and high bad debt provisioning the retail bank focused on operating cost containment as a means of restoring profitability. A large portion of the total cost related to cost of employees. Consequently, a reduction in staff complement was observed in 1999 with a consequent reduction in cost-to-income ratio.

Figure 2.17

Staff complement

Staff numbers
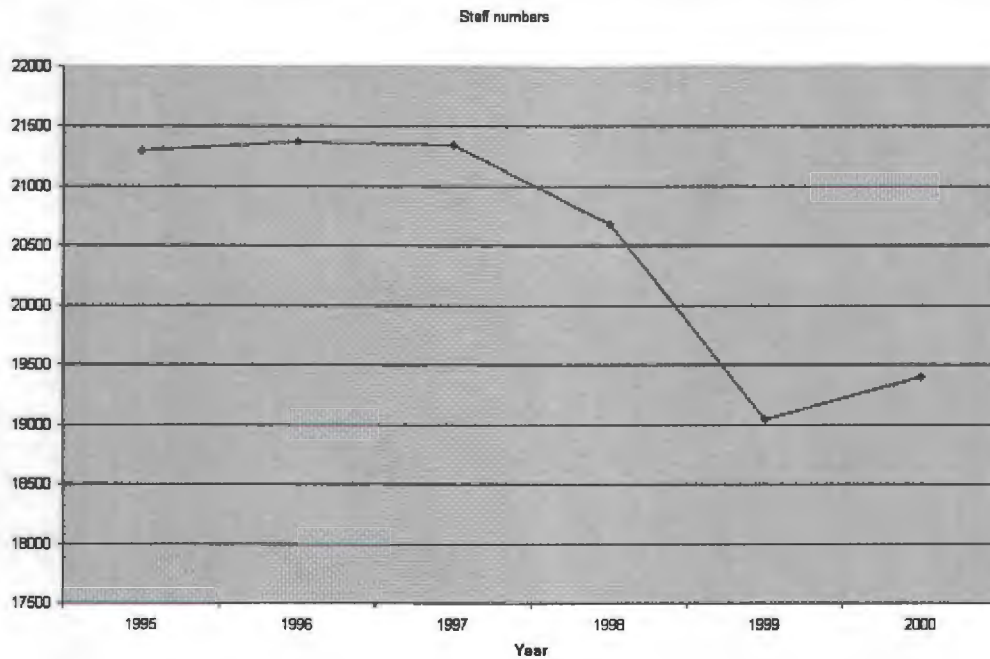
Figure 2.18

Cost-to-income ratio

Cost to income ratio
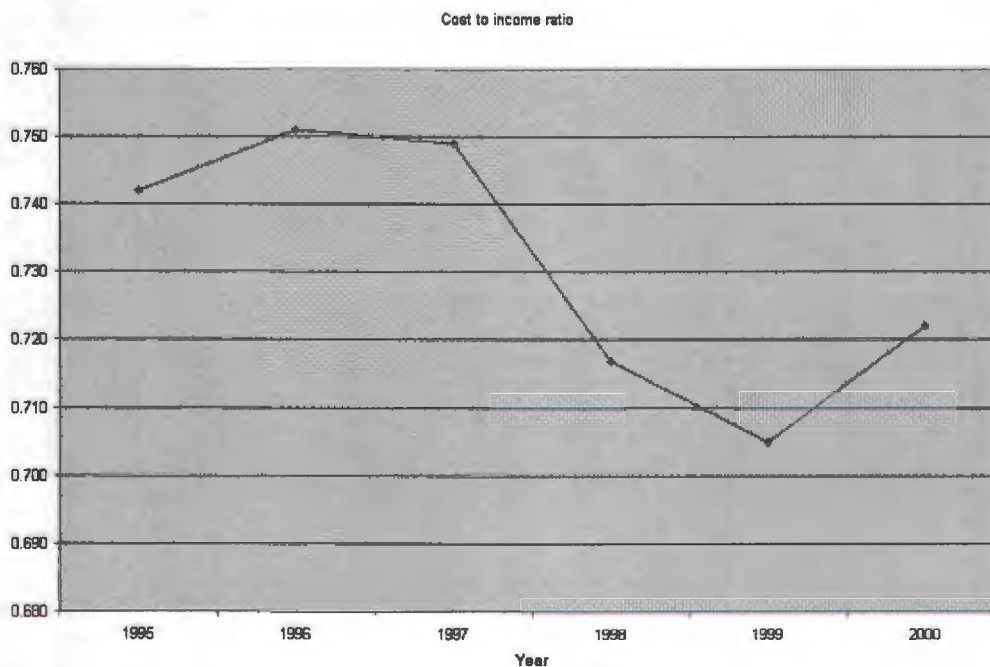
2.5.   The Objectives of the Bank

The bank has set itself a number of objectives over the period 1995 to 2000. These were largely influenced by the market realities and economic conditions it faced. A primary objective of the bank was to generate a return on equity at least in excess of its cost of capital. This required a higher level of net income after tax with it's given resource base. In the face of gradual erosion of margins as competition intensified, the bank aimed at growing higher yielding advances. The bank also set itself an objective of maintaining the bad debt ratio below the industry norm, which was in the range of 0,60% to 0,70% prior to April 1998. In addition, the large exposure of the income streams to interest rate sensitive type of business forced a focus on to non-interest income streams. Despite the growing focus on non-interest income streams, interest income remained a significant contributor to the total income of the bank.

2.6.   Problem Statement

We are now in a better position to define the formal problem statement. The financial performance of the bank is highly dependent on the interest income earned by the bank. Interest income has shown to be highly sensitive to interest rate cycles and is exposed to declining margins. It is our thesis that the dynamics of interest income is a function of a deeper systemic structure and that the observed transient financial behaviour is the response of a peculiar structure to cyclical interest rate movements and other exogenous conditions.

We argue that an investigation into the dynamic behaviour of interest income performance from a resource-based view of the firm and systemic perspective will lead to new insights into the influences and drivers of interest income generation and the impact of alternative strategies on the financial performance of a bank.

Given this, we can formulate the formal problem statement:

To investigate the underlying systemic resource structure responsible for the dynamic behaviour in response to interest rate movements and other exogenous inputs with the purpose of obtaining insight into the behaviour of the structure[1].

Implicit in this statement is the system dynamics modelling perspective as was mentioned in Chapter 1.

---

[1] The statement can also be formulated as a null hypothesis by asserting that a systemic structure does cause the dynamic behaviour. However, due to the nature of the problem and the dynamic complexity, a more realistic objective may be to strive for insight into the nature of this underlying structure and its behaviour.

2.7.   Conceptualising Organisations as Complex Feedback Systems

System Dynamics is predicated on the idea that the performance of an organisation is determined by the underlying structure of organised complexity. This underlying structure can be conceptualised as a set of interacting feedback loops. Viewing the organisation as a complex system of interacting feedback loops contains the essential properties the theory must fulfil to be a dynamic theory of change [Bougon & Komokar: 1990]. To understand strategic change one must be able to conceptualise the organisation as a dynamic system of loops. The feedback loops focus on the dynamic complexity in the form of interdependencies between variables. Feedback loops govern action and change in systems. All actions take place in feedback loops, where feedback loops are closed paths connecting actions to its impact on the system states and the information about the altered states in turn returns as information to influence further action, so closing the feedback loop [Forrester: 1961].

In bounding the model, the investigation should only include within the boundary of the model, those aspects of the system that are necessary to explain the observed reference modes of behaviour. "Only by knowing the question to be answered can we safely judge the pertinence of factors to include or omit from the system formulation. In the first step, however, the investigation of a system should be restricted to a study of it's bare framework and major phenomena; otherwise unimportant detail will obscure the principle lessons to be learned" [Forrester: 1961].

Conceptualisation is achieved by mapping the interrelationships between variables using a graphical mapping tool. The technique of causal loop diagramming (CLD) is an established approach of system dynamics and is applied here to illustrate the hypothesised linkages between variables. However, before the system is described, we digress to briefly discuss the basic principles of causal loop diagramming.

2.7.1.   Causal Loop Diagramming

The causal loop diagram serves as a first step in organising the unstructured set of potential variables in a feedback loop structure. Causal loop diagrams are a powerful qualitative method of representing influences and feedback processes. Simulation models are expressed as a series of mathematical equations and logical statements and are very poor tools for structuring and communicating a feedback problem. Causal loop diagrams assist in structuring a feedback problem, bridging the gap between the problem and the simulation model. Since these diagrams are not technically difficult to apply, it is an ideal tool for structuring and communicating feedback problems among non-system dynamic specialists. Such diagrams display the central beliefs embodied in the model.

2.7.1.1.Representing Cause-Effect Relationships

Feedback loops are structures that consist of *variables* and *links*.

- A *variable* is a quantity that is changeable as time evolves. The variable may be a decision (e.g. product price), a changeable input into a decision (desired market share) or it may be a quantity that is affected by a decision (actual market share).

- A *link* is a cause and effect relationship between two variables. An arrow flowing from the cause variable to the effect variable indicates a link. Thus the direction of the arrowhead indicates the direction of causality.

Figure 2.19 shows the causal relationship between the causal pairs, interest rate and interest income for a financial lending institution. Figure 2.19 indicates that the *level* of the interest rate influences the *level* of interest income, given that *all other factors such as bad debt remain constant.*

Figure 2.19

Causal relationship between 2 causal pairs

Interest rate $\xrightarrow{\ +\ }$ Interest earned
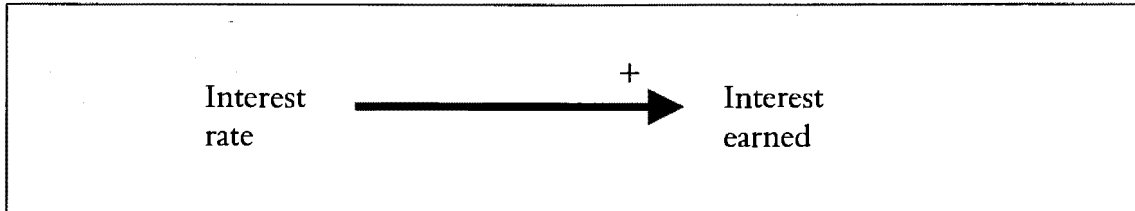
We can distinguish further between the types of causal relationship between the two variables. A positive relationship is indicated by a plus sign on the arrow and indicates that the two variables will change in the same direction. Thus, in Figure 2.19, the causal relationship between interest rate and interest income indicates that when interest rate *increases*, then interest income also *increases*, all other factors being held constant. It also implies that should the level of interest rate *decrease*, then interest income would also *decrease*, all other factors being held constant.

A negative relationship is indicated by a minus sign on the arrow and indicates that the two variables will change in opposite directions. Thus, in Figure 2.20 the causal relationship between bad debt and income indicates that when bad debt *increases*, then income *decreases*, all other factors being held constant.

Figure 2.20

Causal pairs with negative relationship
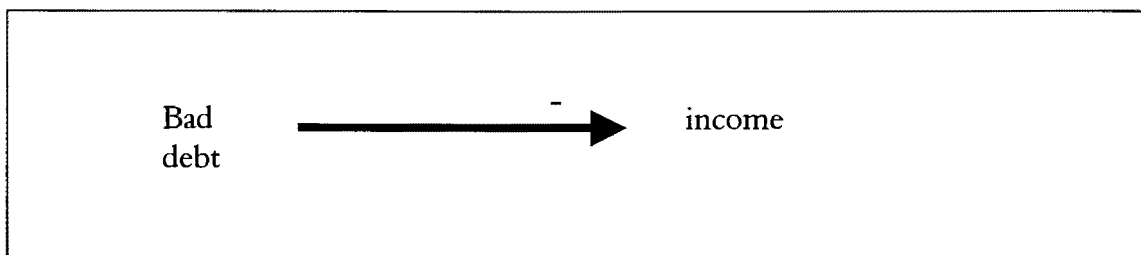
Bad debt $\xrightarrow{\ -\ }$ income

It also implies that should the level of bad debt *decreases*, then the level of income would *increase*, given that all other factors remain constant.

2.16

Thus the arrows between variables indicates that a causal relationship exists between variables x and y. The sign at the head of the arrow denotes the nature of the relationship as follows:

$$x \xrightarrow{\ +\ } y \Rightarrow \frac{\partial y}{\partial x} > 0 \qquad \text{and} \qquad x \xrightarrow{\ -\ } y \Rightarrow \frac{\partial y}{\partial x} < 0$$

An arrow from x to y with a positive sign denotes a positive value for the partial derivative of x with respect to y; an arrow with a negative sign denotes a negative value for the partial derivative.

2.7.1.3.Representing Feedback Loops

Feedback processes can be represented by causal loop diagrams, that is, closed loops of cause-effect. Thus, a feedback loop is a closed loop of cause-effect, and an interdependent set of feedback loops is a feedback system [Richardson & Pugh: 1981].

Figure 2.21 and Figure 2.22 show two pair wise relationships that can be assembled into a feedback loop.

Figure 2.21

Development of first causal pair
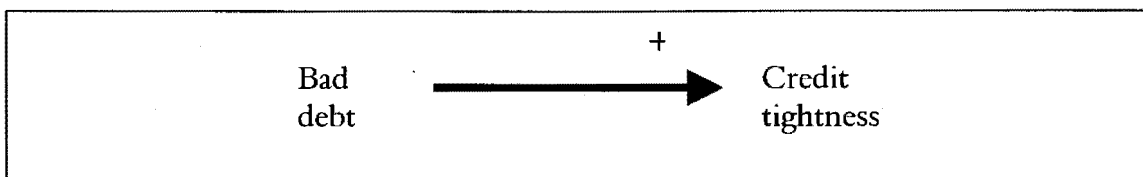
And;

Figure 2.22

Development of second causal pair
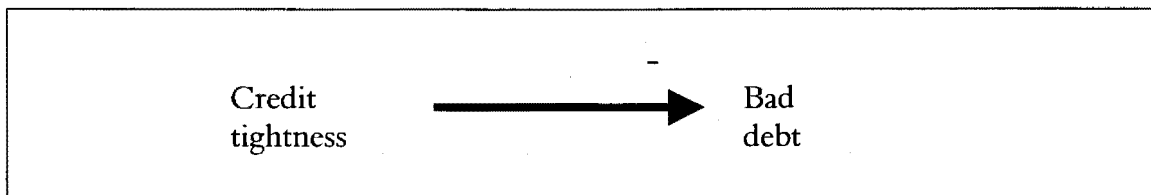
Linking the variables together forms a feedback loop of the system. Figure 2.23 shows the feedback loop for the causal pairs of Figure 2.21 and Figure 2.22.

Figure 2.23

The combined causal pairs as a feedback loop
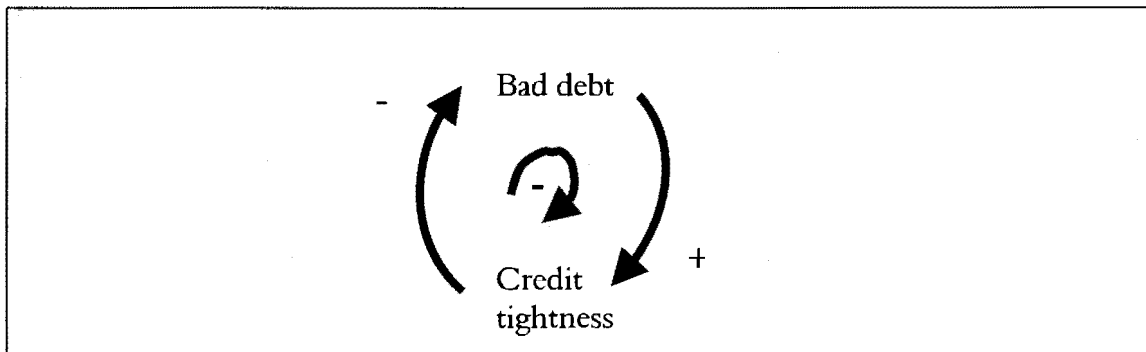
To establish the polarity of this feedback loop, we assume an arbitrary change in the level of one variable, and trace the impact through the loop. We assume that an increase in the level of bad debt occurs, resulting in an increase in the level of credit tightness. An increase in the level of credit tightness results in a decrease in the level of bad debt. Thus the original perturbation (increase in level of bad debt) is suppressed through the iterative action of the loop. The polarity of the loop is shown by the minus sign in the centre of the loop.

When the characteristic loop behaviour is one of reinforcing the original perturbation, the loop is positive.

When the characteristic loop behaviour is one of opposing the original perturbation, the loop is negative or goal seeking.

A *quick test* to determine the polarity of the loop is to multiply out the positive and negative signs around the loop. If the result is:

• Positive, then the entire loop is positive,
• Negative, then the entire loop is negative.

2.7.1.4.Testing the Polarity of Multiple Loop Diagrams.
When the system contains more than one loop, we test each loop individually, holding all other loops outside the loop of interest constant. Such a process results in the establishment of the polarity for each closed loop.

2.8. Causal Loop Diagram of the Hypothesised System

Figure 2.24 illustrates a causal loop diagrammatic description of the hypothesised variables and feedback loop structure for the system under investigation. The causal loop diagram is not a full model representation of the hypothesised system but serves to illustrate the initial hypothesised linkages between key variables. In Chapter 3, the full system dynamics model is developed fully covering the formulation of resource accumulations and rate of change equations, initial values of all resource accumulations, estimates of parameter values and descriptions of non-linear functions. For the sake of clarity Figure 2.24 shows only the primary variables and feedback loops.

Figure 2.24

The interest income system: key feedback loops

2.19
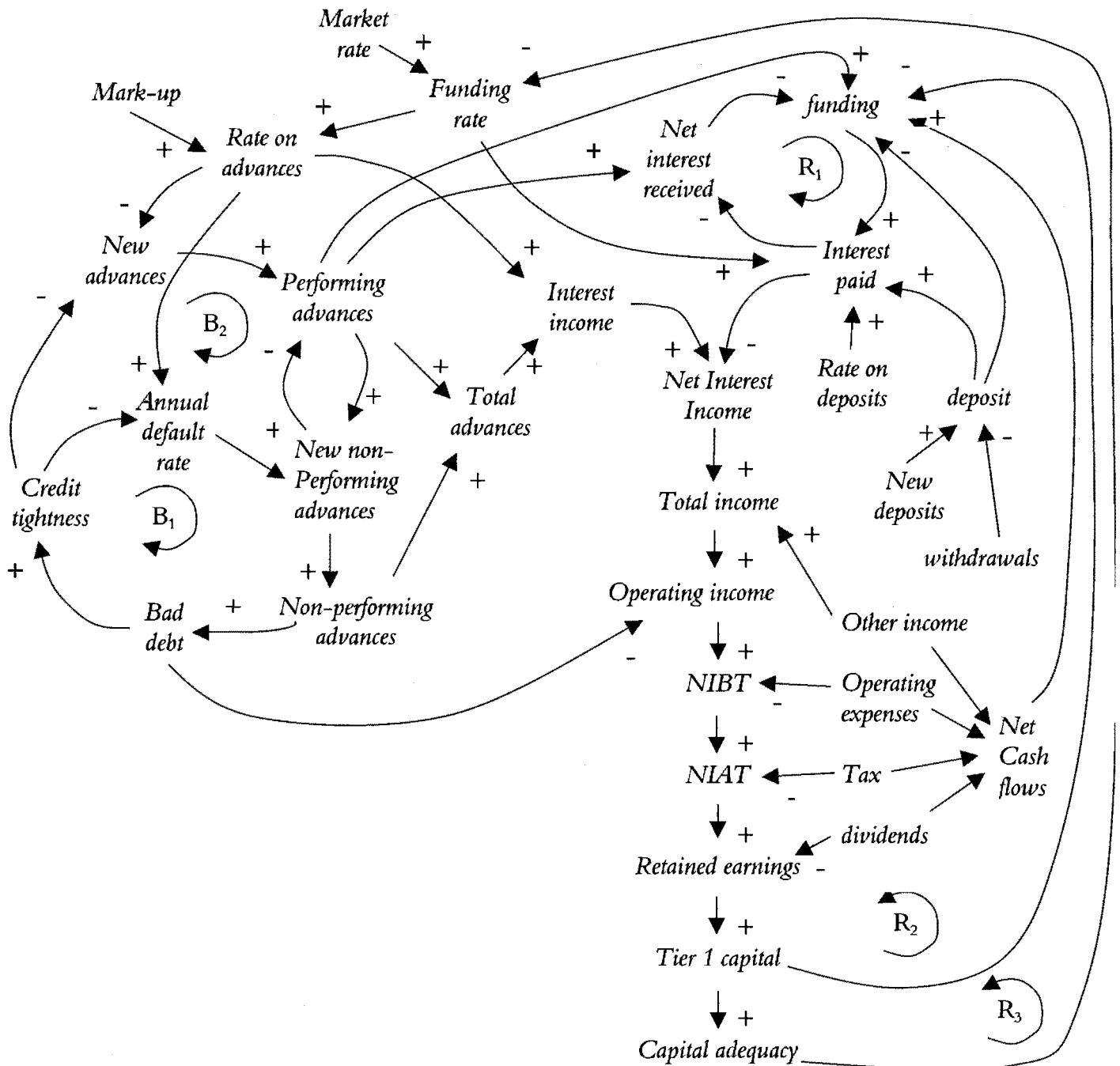
The core resource accumulations in figure 2.24 are the *performing advances*, the *non-performing advances*, the *Tier 1 capital* holdings, the *deposits* and the *funding* accumulations. Each is briefly described below in terms of the variables that increase or decrease the accumulations as well as the interconnections and feedback loops.

Total advances consist of two components, *performing advances* and *non-performing advances*. *Performing advances* is the monetary value of the loans in force on which customers pay interest according to the loan agreement. The core of the lending business is the size of the *performing advances* (loans) book. *New advances* representing new loans issued increases *performing advances*. However, some of the loan holders will default on their loans in force thus increasing the outflow of *new non-performing advances* and in so doing, decrease the size of the *performing advances* resource accumulation.

The value of the *annual default rate* is a key driver of the rate at which *new non-performing advances* occur. The higher the *annual default rate*, the higher the rate of flow of *new non-performing advances*, increasing the stock of *non-performing advances*. The higher the level of *non-performing advances*, the higher the *bad debt* can be expected to be. *Bad debt* occurs when there is very little chance of recovering the non-performing loan capital from the loan holder. *Bad debt* is a policy decision to write-off *non-performing advances* that reduces the stock of *non-performing advances*.

An increase in *bad debt* will lead to a tightening of credit (lending) practices. This in turn will have the effect of eventually suppressing the *annual default rate*. This closes the loop B_1. Loop B_1 serves as a balancing mechanism that seeks equilibrium and prevents *bad debt* and *non-performing advances* from escalating to an unacceptable level.

A second effect of increased credit tightness is the reduction in *new advances*. This in turn suppresses the rate of growth of *performing advances*. This gives rise to the balancing loop B_2. The function of this loop is to suppress the growth in new loans when *bad debt* is growing in an attempt to stem the acceptance rate of poor quality advances.

Interest is earned, by the bank, from the book of *total advances*. The *net interest income* is an accounting concept, the net position of *interest income* and *interest paid*. *Interest income* is an accounting reflection of *interest income* on *performing advances* as well as *interest income* on *non-performing advances* even though no interest payment has actually been received on the stock of *non-performing advances*. *Net interest income* is a key determinant of *total income* that in turn is a key driver for *operating income, net income before tax (NIBT), net income after tax (NIAT), retained earnings* and *Tier 1 capital* holdings.

Interest received reflects the cash received from *performing advances* only. This reflects a cash flow view as opposed to an accounting view. The more *interest received*, the more cash available to the bank and thus the less the *funding* required to cover the shortage of *deposits* over *total advances*. Funding is affected by other cash flows in the bank, over and above the flows of *performing advances* and *deposits*. Other income such as non-interest income as well as cash flows such as *operating expenses, tax* payments and *dividend* payments either increase or reduce the *funding* requirement of the bank. Interest is paid on the funding pool. The larger the *funding* pool, the greater the *interest paid*, reducing the *net interest received* increasing the *funding* requirement further to compensate for the additional *interest*

2.20

paid. This feedback loop is labelled R_1 and is a reinforcing loop that magnifies the impact of any increase in *funding* to increase the *funding* requirement further. A reinforcing loop is, however, also a double-edged sword; the lower the *funding* pool, the less the interest paid on *funding* that, in turn, results in a higher level of *net interest received*.

An increase in *retained earnings* results in an increase in *tier 1 capital* improving the capital position of the bank. The higher the level of capital, the less funding is required by the bank, reducing the *interest paid*, increasing *net interest income* that eventually feeds through to a higher *retained earnings* and a further increase in *Tier 1 capital*. This loop is designated as feedback loop R_2.

The higher the capital holdings of the bank, the higher the *capital adequacy* ratio. The *capital adequacy* of a bank impacts on the bank's ability to raise funds in the market, which is primarily impacted through the *funding rate*. The *funding rate* is the rate the bank pays in the market to raise funds. The better the *capital adequacy* ratio of a bank the lower the *funding rate* will be. A bank with a poor *capital adequacy* is likely to have a poor credit rating and will have to pay a premium for its funds due to the perceived risk attached to lending to such an institution. A reducing *capital adequacy* may lead to an increase in the *funding rate* leading to an increase in *interest paid* that reduces the *net interest received* eventually reducing *retained earnings*. This closes a positive feedback loop R_3 that serves to improve the level of the *funding rate* of the bank. The relationship between *capital adequacy* and *funding rate* is a non-linear relationship. On the other hand, the more capital held, the lower the return-on-capital will be. Thus, there is a penalty associated with holding excess capital.

A number of feedback loops have been identified in the diagram above. All of the loops are not necessarily dominant all of the time. Thus, for example, the *capital adequacy – funding rate* is governed by a non-linear relationship and the loop may become dominant only when the capital adequacy of the bank falls below the regulatory minimum requirement. Several other linkages and feedback loops can be identified from Figure 2.24. The above narrative description serves to introduce the feedback structure that is formally developed in Chapter 3.

Chapter 3

Formulating the Hypothesis - A Dynamic Resource Systems View.

3.1. Introduction

A modelling strategy that is used throughout this research is to identify the processes of key strategic resource accumulations, build a dynamic hypothesis of cause-effect and feedback loops around this resource structure, relating financial flows to this resource structure. The model of the structure is then initialised with key resource accumulations representative of those of the Retail Banking division of a South African Financial Services Group as at 1 April 1995 and is provided with a replication of the exogenous inputs (e.g. interest rates) over the modelling time horizon as well as the policy variables representative of those implemented by the bank. The model is allowed to generate a set of resource accumulations and financial flows that is compared to the actual flows and resource accumulations over the period 1 April 1995 to 31 March 2000. The simulation time interval was set at one month, i.e., the model generates data for monthly intervals. This output is compared to the actual performance, as experienced by the Bank, and is used as a primary method of determining the validity of the model. However, behavioural validity must be supported by structural validity, i.e. the right performance for the right reasons. Structural validity, the second primary test of validity was achieved by comparison of the model with known cause-effects and resource accumulations and by exposing the model to knowledgeable executives for scrutiny. Several other validation tests were undertaken, these are to be discussed in further chapters.

The model, in its initial phase, was calibrated to the historical behaviour of a particular bank. However, once validated, the model provides a structural explanatory theory that may be applicable to numerous situations, that is, it is generalizable to a wide variety of appropriate situations for banks with similar underlying generic structures.

3.2. The Dynamic Resource-Systems View.

In describing the interest income generating system it is useful and insightful to interpret the system in the framework of the dynamic resource systems view as develop by Morecroft, Warren and colleagues at the London Business School [Morecroft: 2000]. The dynamic resource-systems view combines the language of system dynamics with the interpretive framework of the resource-based view of the firm into a dynamic explanatory framework for understanding how competitive advantage arises in firms over time. Whilst the dynamic resource-based view has been utilised to explain competitive advantage of firms, this dissertation focuses on a more limited part of a larger banking business. Thus the boundary of the business under study is drawn much smaller than would be required for a full study of the factors that give rise to competitive advantage but is drawn widely enough to achieve the objectives of this study. Even so, it is helpful to apply the language of the resource-based view in interpreting how performance arises in our system under study.

Conventional resource-based view suggests that the performance of a firm is a direct result of the unique configuration of its resources [Grant: 1995]. Thus, if one bank displays superior performance in generating interest income it is because that bank has managed to assemble a better blend of resources such as the deposits book, advances book, capital, credit assessment staff, reputation as a safe haven for deposits, etc, than its competitors without paying more for those resources. It is the way that these resources are deployed to serve the market that determines the performance of a business.

Generally, resources of a firm are not acquired as a once-off opportunity but are steadily accumulated over time [Dierickx & Cool: 1989] – a loans book of a bank is built up steadily over a period of time by adhering to a consistent set of policies that governs the flow of new loans to the bank. Similarly, resources may decay over time; for example, a client base of a bank may decline over time.

Using the system dynamics methodology, the resources that underpin the performance of a business can be visualised as stocks, depicted as rectangles in the example of Figure 3.1. Resources accumulate in the stock as new resources flow into the stock over time and the resource depletes by flowing out of the stock. The graphs in the stock and above the flows depict the level of the stock and rate of flow over time.

Figure 3.1

Resource accumulation
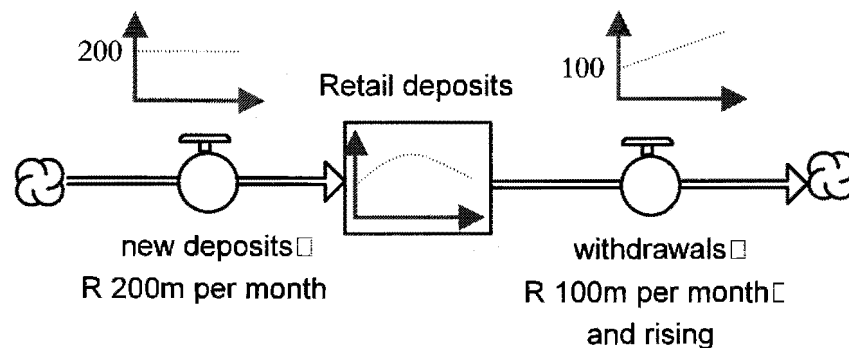
Solid arrows flowing into or out of the stocks depict flows, and the stocks are integrations of those rates of flow. Thus,

$$L_t = L_{t-1} + \int_{t-1}^{t} (inflow - outflow)dt$$

where:

L_t = stock variable at time (t), and
L_{t-1} = value of stock variable at (t-1)

For example new deposits gained per month increases the stock of retail deposits whilst withdrawals per month depletes the stock of retail deposits. Flow rates are not instantaneously observable but are measurable over a period of time. By tracking the

trajectory of the level of resources over time we can obtain a view on how the inflows and outflows have built or decayed the resource.

Dierickx and Cool identified the dynamic nature of inertia of resource accumulations. The dynamic characteristic of resource accumulations is that resources take time to accumulate through the inflow of new resources. A resource can only be changed by a consistent pattern of resource flows (the stock has inertia and resists instantaneous change). Whilst flows can be adjusted instantaneously, resource accumulations cannot. This places a fundamental constraint on strategy change. Dierickx & Cool deduce that a key task of strategic management is to make appropriate choices and consistent policies to govern the resource flows to accumulate a desired level in key resource stocks over a sustained period of time.

3.2.1. Complementary Resources

For a firm to gain competitive advantage through its set of resources, those resources must support each other. Figure 3.2 illustrates a reinforcing feedback structure that supports the growth of two different resources.

Figure 3.2

Example of reinforcing feedback
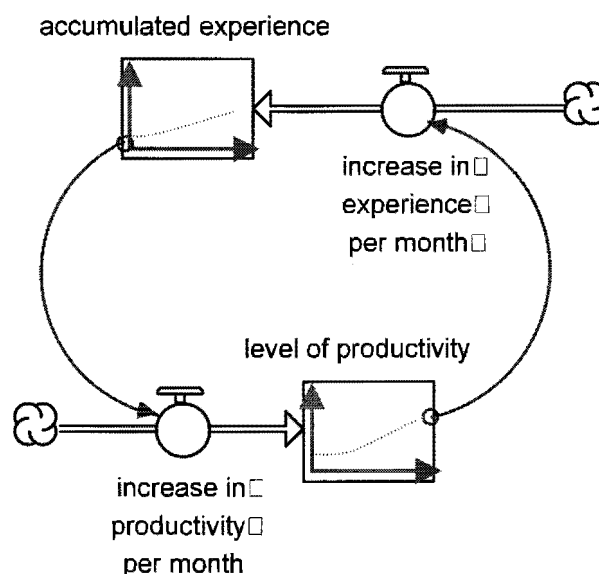
In this type of structure, the rate of growth of each resource is dependent on the current level of the stocks of resources in the system. The closed feedback loop structure results in a particular type of dynamic performance. In this type of structure, each resource feeds off the growth of the other resource resulting in a system that is capable of reinforcing its own growth. Figure 3.2 illustrates this. As the accumulated experience of the workforce increases, the rate of productivity increases resulting in a higher level of productivity for the workforce. As the level of productivity increases, so the workforce gains experience more rapidly, closing the feedback loop. This feedback structure is known as a positive

feedback loop – refer also to section 2.7 on causal loop diagrams and positive and negative feedback loops.

Just as the relationships between certain types of resources can lead to feedback structures that reinforce growth, so complementarity may also arise in the form of balancing feedback structures that are goal seeking in an effort to retain some equilibrium state of a system. Such balancing loops constrain growth. Figure 3.3 illustrates two of these loops.

Figure 3.3

Example of balancing feedback
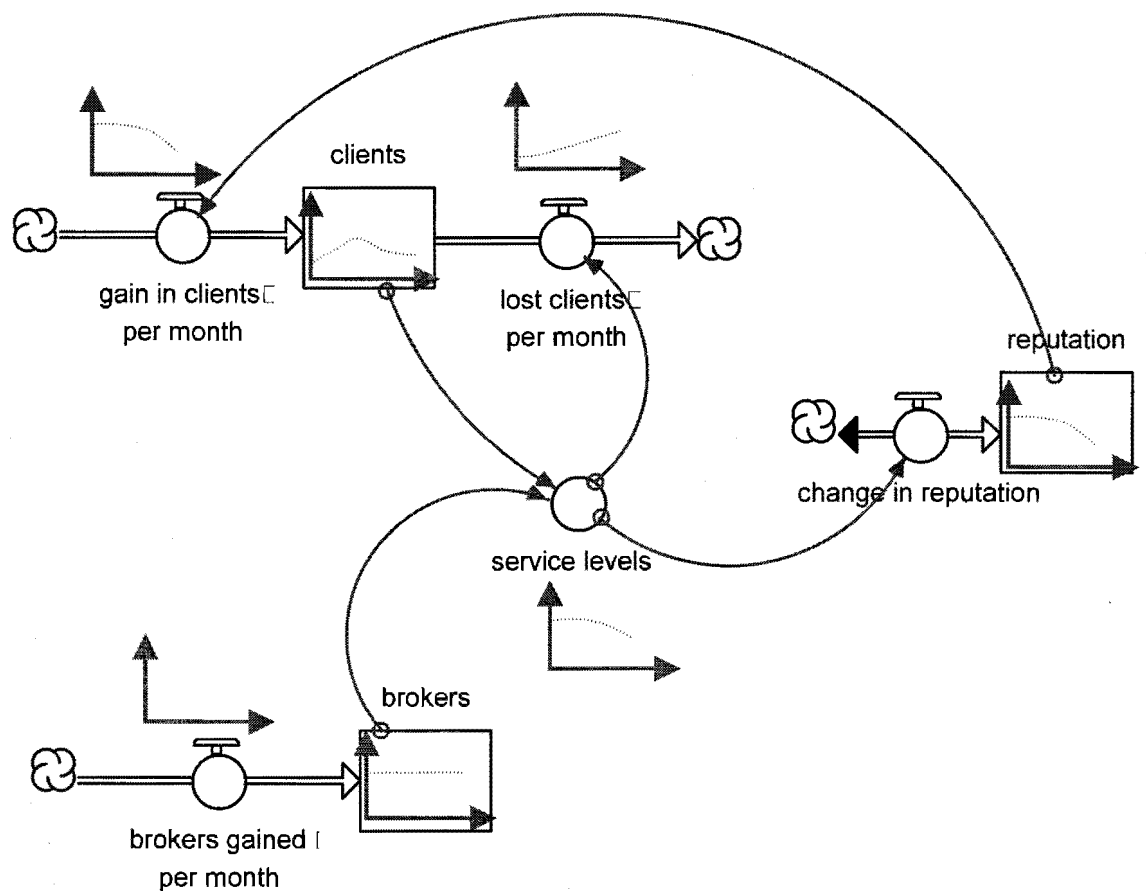
Consider the case of an insurance broker; the number of clients is increasing whilst the number of brokers remains constant with no brokers being hired. As a result, the brokers are increasingly swamped with work resulting in declining service levels. The declining service levels eventually reaches the ears of the market with a decline in reputation following on. This results in a decline in the number of new clients gained per month retarding the growth of the client base. This is the first loop that constrains the growth of the firm. The second loop at play occurs when service levels decline, existing customers also find the service unacceptable and leave for another broker, thus reducing the number of clients. This has the effect of restoring the balance between clients and

brokers which leads to a restoration in service levels. This is the goal-seeking nature of this kind of feedback loop that attempts to maintain an equilibrium position.

The above two examples illustrate the two basic types of complementarity that exists between resources; the reinforcing loop and the balancing loop [Warren: 1999]. A resource system of complex feedback loops often leads to counter-intuitive behaviour and unintended consequences. Consider the broker example of Figure 3.3; the dominant logic of the management may be to be a "lean and mean" firm, attracting new clients to gain revenue but restricting the growth in brokers. This may possibly lead to an unsustainable strategy since the initial growth is followed by a decline phase and a return to a lower level of activity as the system attempts to restore an internal balance.

Two terms that will be used in this dissertation are "capability" and "policy". We now clarify the meaning of these two terms. Policies are the "decision rules" that govern the resource flows. Stocks and flows are embedded within a feedback structure [Forrester: 1961]. Consider the broker resource of Figure 3.3. The firm may wish to attain a particular desired level of brokers (the goal). The desired level of brokers is compared with the actual number and the discrepancy is noted. The firm then takes corrective action to close the gap between desired number of brokers and the actual number. The rate at which corrective action is taken depends on the size of the discrepancy and on the time required to correct the gap. Corrective action controls the flow of brokers into and out-of the resource stock. The key here is that the policy guides the flow of resources. Policies are rules based on the flow of feedback information. A policy shows how managers select, prioritise and process information when controlling the flows of resources [Morecroft: 2000]. Change the policies and the rates at which the resource accumulates may also change. Policy changes often require different information sources to guide future decisions.

"Capability", on the other hand, refers to the firm's ability to build both the individual resources and the resource system as a whole [Warren: 1999]. For example, a bank may have a lower loan default rate by assessing its client's risk profile better than a rival can with the same amount of staff and expenditure. Both policies and capabilities are indicated as thin arcs on our resource diagrams such as Figure 3.3.

The time path of a firm's performance can be derived from the evolution of its resource system [Warren: 1999]. For example, the financial performance generated by a bank from its loan business is a direct result of the size of its loan book, the quality of the loan book, the amount of deposits it can muster to fund the loan book, the amount of capital it has to enable it to grow the loan book, etc. The time path of its performance is dependent on the time paths of the resource accumulations, i.e. how the loan book accumulates over time will directly influence the income earned from that loan book. Individual resources, such as a loan book, hold no competitive advantage on their own, but the unique configuration of resources determines the performance of the entire system [Warren: 2000]. Thus resources are interdependent and the growth or decline of some resources are dependent on the states of the other resources [Forrester: 1961]. The dynamic resource systems view provides a framework from which to identify key resource, track the time paths of the evolution of the resources and infer the resulting performance of the business.

Warren, applying the dynamic resource systems view, and building on the concepts developed by J. Forrester, deduces the following:

- If performance depends on resource-levels, and these accumulate and deplete over time, there is no way to explain performance at any time except by knowing all gains and losses to all resources over the entire history of the firm.
- There is similarly no way to produce a confident view of future performance without estimating how those gains and losses develop.
- There is no way for management to alter the strategic performance of the firm except by actions that impact on resource-flows (though short–term performance can be changed by making simple allocation choices, especially between expenditure and declared profits).

3.3. The Interest Income Generating System

The key resources identified in Chapter 2 are the *performing advances, non-performing advances, retail deposit, funding, capital, liquid reserves* and *quality of loan book*. Our hypothesis is based on the idea that the financial performance of the system is dependent on the accumulations of these key resource stocks.

Whilst all but one of these stocks are financial in nature, they should not be confused with the financial flows of the firm. These resources are the stocks in trade for a bank. For lending banks, the stock in trade is money, that is, banks borrow and lend money as its basic resource, analogous to a retailer that purchases and sell goods. The retailer's financial performance is dependent on its resource accumulation of goods. Similarly, a bank's financial performance is dependent on its resource accumulations of advances, deposits, funding, etc. The financial performance can only be calculated once the resource accumulations are specified. *"Financial flows are the speedometer of the business, not its substance"* [Warren: 1999].

Figure 3.4 illustrates the key resources for the interest income generating system as well as their interdependencies. Figure 3.4 provides a view on the complete model using system dynamics principles. The model is separated into several unique sectors, each sector being identified by a sector rectangle containing resource accumulations. We will now discuss each key resource accumulation and it's information feedback processes in more detail. Figure 3.4 shows a high level of interaction between variables governing the state of the interest income generation system. This complexity is decomposed for each resource accumulation and is discussed in more detail below. The composition and operation of the entire system is discussed at the end of this chapter. The ithink software code for the model is documented in Appendix A.

Figure 3.4

Structure of key resources
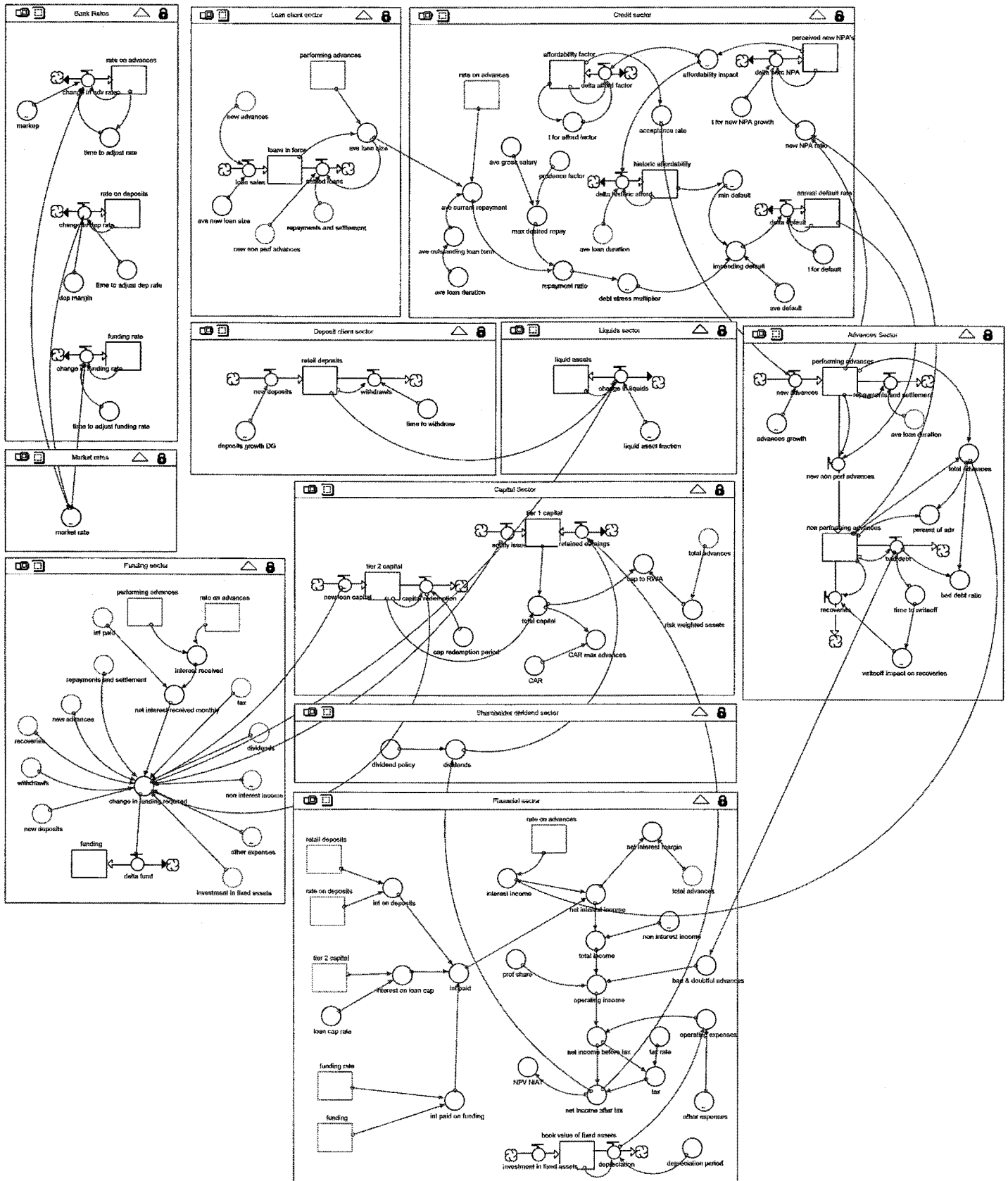
3.3.1. The Performing Advances Resource Accumulation

Figure 3.5 illustrates the stock and flows that affect the accumulation of the loan book (*performing advances*) in the Advances Sector. *Performing advances* is a stock variable that is increased by the Rand value of *new advances* (new loans issued) and is decreased by *repayments and settlements* of loans by loan holders as well as by *new non-performing advances*.

─── **Figure 3.5**

Performing and non-performing advances

writeoff impact on recoveries
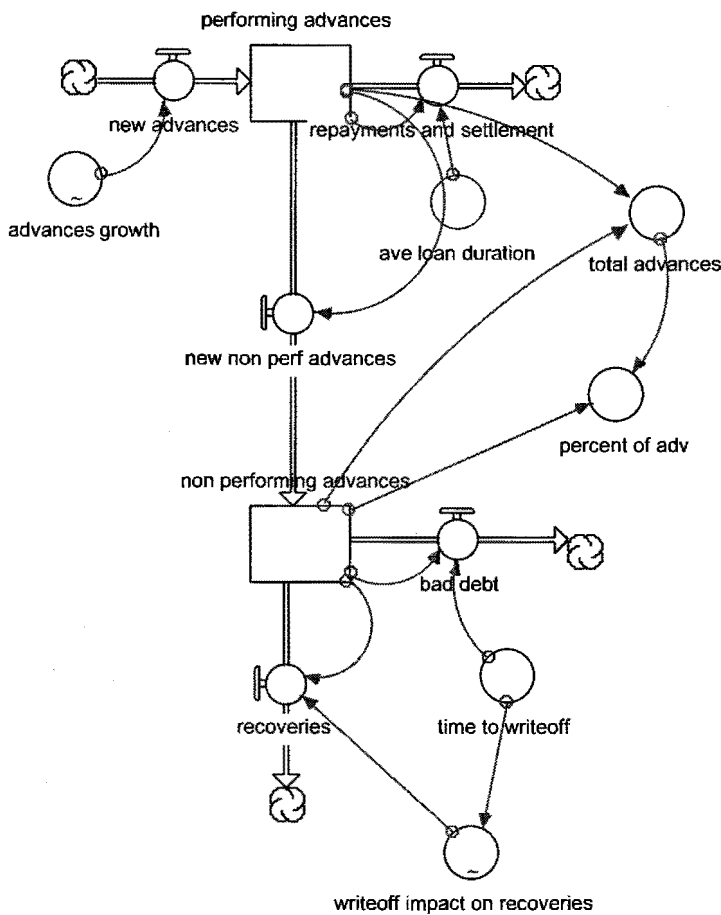
New advances, the inflow that increases the stock of *performing advances*, is driven by an exogenous variable, *advances growth*. *Advances growth* is a function of the market demand as well as operational factors. The development of the *advances growth* is beyond the scope and aims of this research (and beyond the boundary of the model) and is provided as an exogenous input into the model. The *advances growth* is based on the historic advances as experienced by the bank over the period 1 April 1995 to 31 March 2000. The growth in advances is described by the graphical relationship using Cartesian co-ordinates. The *x* co-ordinates represent time periods in months starting from time period 1 at 1 March 1995. All graphical functions described herein will follow this format.

```
advances_growth = GRAPH(TIME)
(1.00, 1.166e+009), (6.36, 1.342e+009), (11.7, 1.518e+009), (17.1, 1.386e+009), (22.5,
1.364e+009), (27.8, 1.474e+009), (33.2, 1.562e+009), (38.5, 1.567e+009), (43.9,
1.567e+009), (49.3, 1.43e+009), (54.6, 1.267e+009), (60.0, 1.254e+009)
```

Figure 3.6 illustrates the advances growth. The advances growth was derived from the available bank data for the changing stock of performing advances. By using the bank data for the stock of performing advances, as it evolved over the time horizon, and with the knowledge of the outflows of loans, the inflow was derived.

Figure 3.6

Advances growth (monthly new advances)
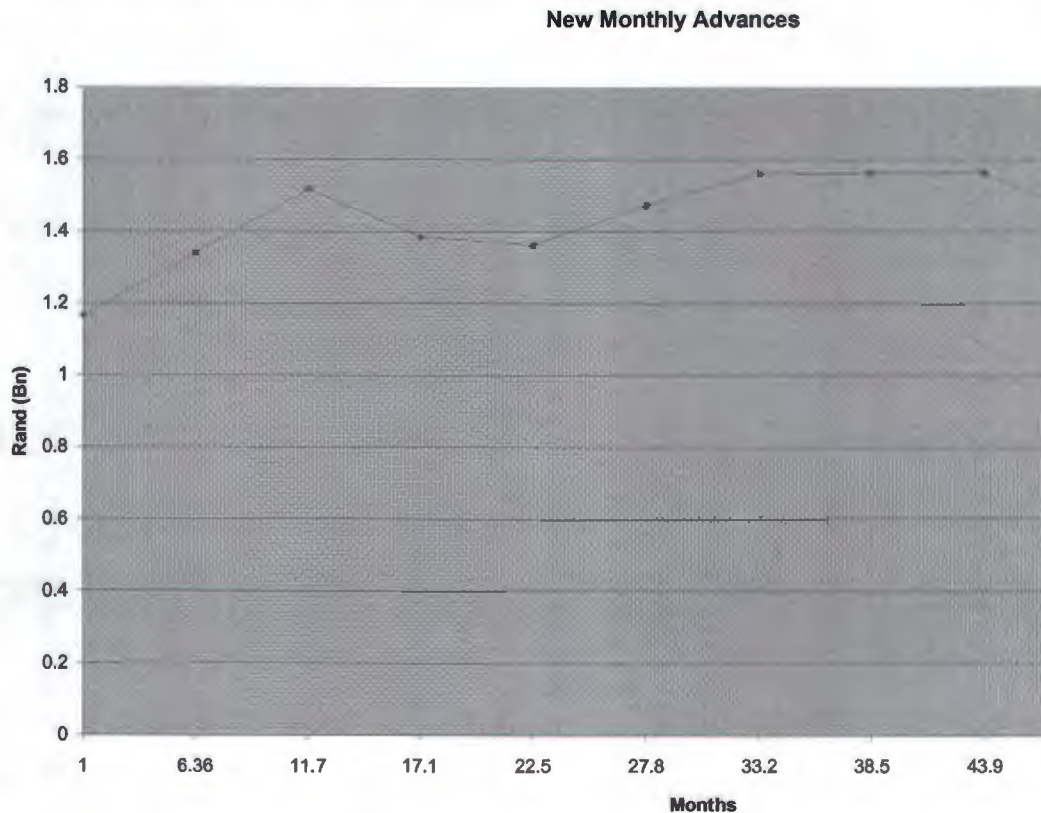
The rate of outflow *repayments and settlements* is governed by a feedback loop that creates the rate of *repayment and settlements*, which depletes the stock of *performing advances*. This is a first-order negative feedback loop that generates typical equilibrium seeking behaviour. In the absence of any new inflows, the negative feedback loop would cause the loan book to decline towards zero in an exponentially decaying mode of behaviour. The rate at which the outflow *repayments and settlements* depletes the stock of *performing advances* is a function of the value for the coefficient *ave loan duration*. This coefficient represents the average period that elapses before a loan is settled. The value of the outflow rate is a function of the size of the *performing advances* stock and the value of the coefficient *ave loan*

duration. As the size of the stock of *performing advances* grows, so does the rate of *repayments and settlements.* The average period for the aggregate stock of loans is 84 months (seven years).

The characteristic of the delay of performing advances may be more accurately described by a higher order delay. Whilst the average duration of a loan is specified fairly accurately, the distribution of the settled loans flowing out of the performing advances stock around the mean duration is likely to be different to the exponentially declining mode of behaviour of the first-order feedback structure. The distribution of the settled loans is more likely to be approximated by a higher order feedback structure but not by a pipeline delay where the settled loans flow out in the same order as the order at entry [Sterman: 2000]. The actual distribution would lie between the first-order delay and the pipeline delay. The model was built using first-order feedback structures for all the resource accumulations with the intention of testing the model behaviour first, and if found unsuitable, would lead to the modification of the order of the resource feedback structure. The reason for this was the difficulty associated with obtaining the necessary information about the outflows and inflows of individual loans and deposits – a mammoth task which may not be necessary. The behaviour of the system with first-order structures produces a reasonably accurate replication of the behaviour of the actual system, as will be demonstrated in Chapter 4.

The second outflow, *new non-performing advances* is a reclassification of *performing advances* into a new category: *non-performing advances.* A loan becomes non-performing when the debtor ceases to make repayments. In such a case, the loan ceases to earn interest. Classifying advances into *performing advances* and *non-performing advances* ensures that *interest income* (in the financial sector) can be calculated from the stock of interest earning loans, that is, from the stock of *performing advances* only. The rate of *new non-performing advances* is governed by a first-order negative feedback loop that generates equilibrium seeking behaviour. In the absence of any new inflows, the negative feedback loop would cause the loan book to decline to zero in an exponentially decaying mode of behaviour. The rate at which *new non-performing advances* are generated is a function of the value of the *default rate* and the size of the *performing advances stock.* The *default rate* is discussed in detail in the section on the credit management process discussed below.

The equations in ithink software code syntax are as follows:

```
performing_advances(t)   =   performing_advances(t  -  dt)   +   (new_advances  -
repayments_and_settlement - new_non_perf_advances) * dt

INIT performing_advances = 53.276e009


new_advances = (advances_growth*acceptance_rate)

repayments_and_settlement = performing_advances/ave_loan_duration

new_non_perf_advances = performing_advances*annual_default_rate/1200
```

3.3.2. Non-Performing Advances Accumulation

Loans for which repayments have gone in arrears are classified as non-performing loans. The bank attempts to recover the capital and accrued interest on the loans where possible and the balance is written-off as bad debt. Non-performing loans and bad debt have a significant impact on the financial performance of a bank. The funding of the loan capital written off must continue to be funded. In addition, new assets must be created to make up the cost of funding the bad debt or non-performing loan.

Referring to Figure 3.5, the stock of *non-performing advances* is increased by the rate of flow of *new non-performing advances* and is decreased by the rate of *recoveries* and rate of bad debts. *Recoveries* is an attempt to recover the capital amount of the loan, *bad debt* is the writing-off of loans that are deemed to be irrecoverable. Both outflows are governed by first-order negative feedback loops. The rate of *bad debt* is a function of the coefficient *time to write-off*. This represents a policy (decision rule) of the decision agents controlling the rate of *bad debt*. Different banks are likely to have different write-off policies depending on the dominant logic and world-view of the decision agents controlling the policy. The rate of recoveries is a function of the coefficient *write-off impact on recoveries*. This coefficient represents the efficiency with which the organization can recover the capital amount of the outstanding loans. The greater the effectiveness of the organization in recovering outstanding capital, the higher the value of the coefficient.

---

non_performing_advances(t) = non_performing_advances(t - dt) + (new_non_perf_advances - bad_debt - recoveries) * dt

INIT non_performing_advances = 0.0065*performing_advances

new_non_perf_advances = performing_advances*annual_default_rate/1200

bad_debt = non_performing_advances/time_to_writeoff

recoveries = non_performing_advances*writeoff_impact_on_recoveries/12

Total advances is the sum of the *performing advances* stock and the *non-performing advances* stock. *Percent of adv* calculates the *non performing advances* as a percentage of *total advances*.

---

total_advances = non_performing_advances+performing_advances

percent_of_adv = (non_performing_advances/total_advances)*100

3.3.3. The Stock of Client Loans

The stock of client loans is a co-flow (coincident flow) structure [High Performance Systems: 1997]. This represents the flows and accumulation of the number of loans issued. This resource accumulates in parallel with the performing advances resource. The resource *performing advances* tracks the monetary value of the co-flow, *loans in force*, whilst the resource *loans in force* tracks the number of loans. The inflow of the *performing advances* stock is directly linked to the inflow of the *loans in force* stock. The coefficient *ave new loan size* is the conversion factor to convert the monetary value of *new advances* to *loan sales*. Similarly, the outflow from *loans in force*, *settled loans*, is directly linked to the outflows of performing advances (*repayments and settlement, new non performing advances*) and converted to number of loans settled.

Figure 3.7

Loans in force resource
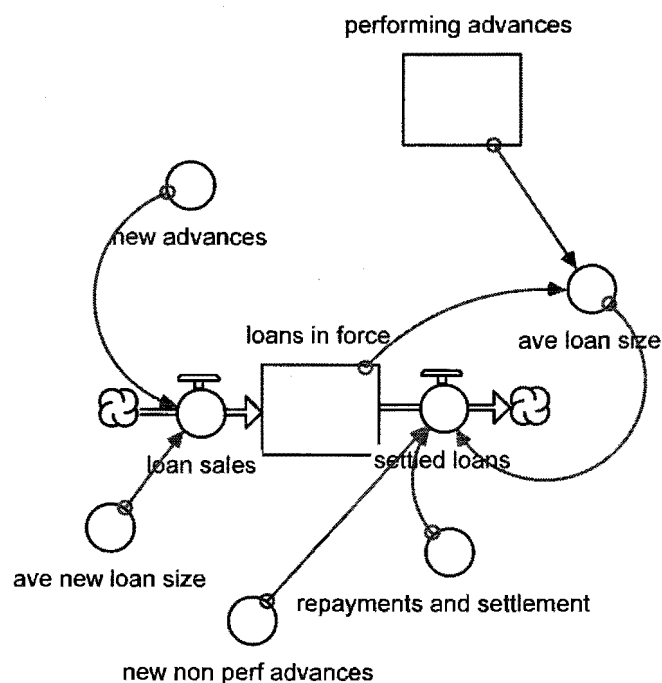

```
loans_in_force(t) = loans_in_force(t - dt) + (loan_sales - settled_loans) * dt

INIT loans_in_force = 500000

loan_sales = new_advances/ave_new_loan_size

settled_loans = (new_non_perf_advances+repayments_and_settlement)/ave_loan_size

ave_loan_size = smth1(performing_advances/loans_in_force,1)

ave_new_loan_size = 150000
```

3.3.4. The Policy Structure of the Credit Management Function

Credit risk is the risk that a financial contract will not be honoured according to the original set of terms or expectations [Belgian Banker's Institute: 1998]. Credit risk remains a leading cause of bank bankruptcies throughout the world. From a bank's perspective, the challenge is to achieve advances growth targets whilst maintaining or increasing the quality of a bank's loan portfolio. The higher the quality of the portfolio, the lower the risk of credit default. The higher the growth in advances the greater the proportion of poorer quality loans that must be taken on board to meet the growth targets. Thus there is a trade-off between meeting advances growth targets and developing a high quality of loan book.

Figure 3.8 illustrates two negative feedback loops that attempt to control bad debt; the first loop is a policy (decision rule) loop controlled by the decision agents in the credit process, the second loop is function of the quality of the loan clients for which loans have been written.

Figure 3.8

Negative feedback loops regulating performing advances
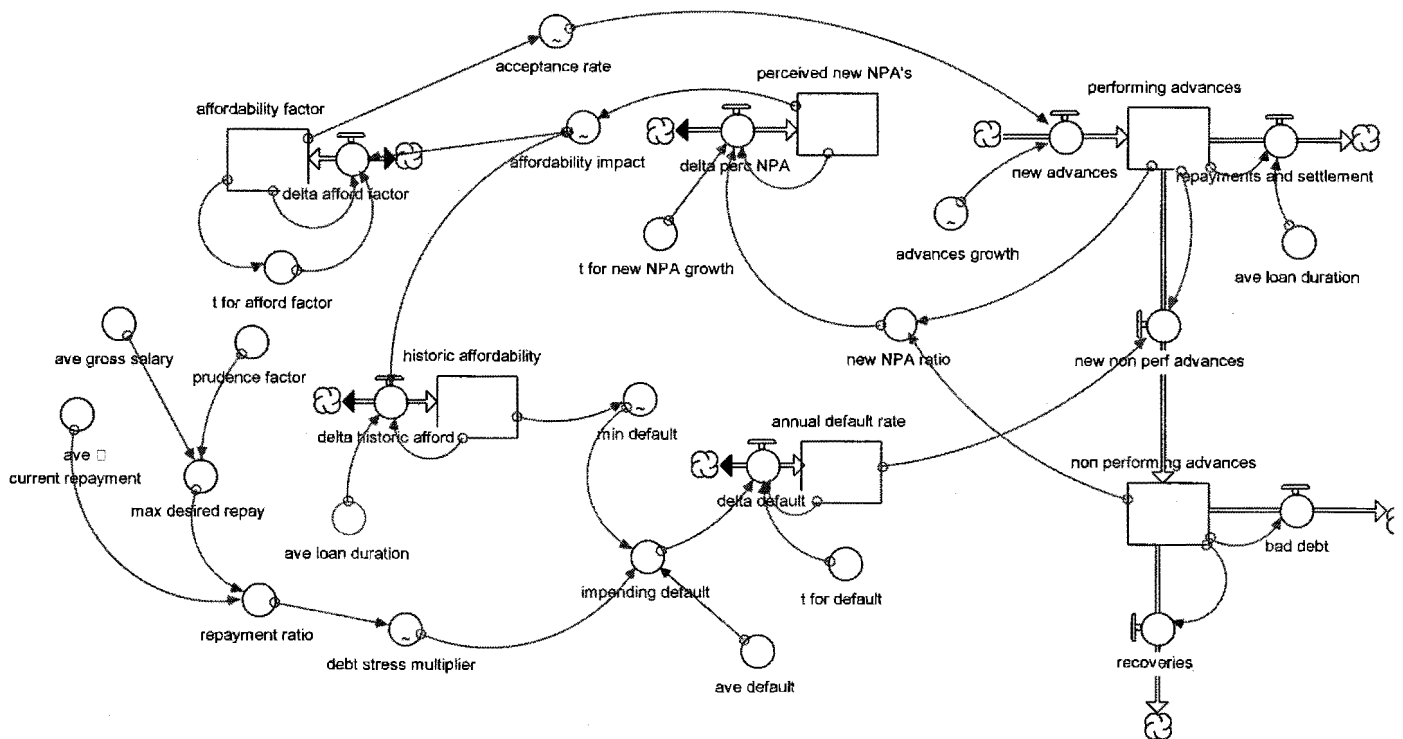
Starting near the right-hand side of Figure 3.8, the ratio of *non-performing advances* to *performing advances* is measured as the *new NPA ratio* on a monthly basis.

```
new_NPA_ratio = non_performing_advances / total_advances
```

Non-performing advances is increased by the monthly inflow of *new non-performing advances*. The rate of flow of *new non-performing advances* is a function of the *rate on advances* (not shown in Figure 3.8) that is, the interest rate payable by the loan holder. This rate is variable and is adjusted by the bank, that is, it is a policy variable. The higher the *rate on advances*, the higher the expected *default rate*. The rate at which *new non-performing advances* are generated may be irregular due to individual events that occur.

The managerial action that needs to be taken concerning the credit management depends on the underlying trend in *new NPA ratio* ignoring the superficial fluctuations and short-term noise. Full and immediate action is not taken to tighten credit processes when there is an increase in *new NPA ratios* but is delayed until a clear trend has been established. This psychological process is represented by a smoothing process taking a series of past monthly *new NPA ratio* and forming an estimate of the present rate of flow of *new NPA ratio*. This process is represented by the stock of *perceived new NPA's*. The monthly *perceived new NPA's* is an exponential smoothing of the past monthly *new NPA ratio* with an averaging period of 3 months. The result is twofold; smoothing of the *new NPA ratio* attenuates any short-term noise in the data and, in the process creates a time delay characteristic of information smoothing processes. Smoothing also changes the sensitivity of the system to different frequencies that exist in information fluctuations [Forrester: 1961].

```
perceived_new_NPA's(t) = perceived_new_NPA's(t - dt) + (delta_perc_NPA) * dt

INIT perceived_new_NPA's = new_NPA_ratio*100

delta_perc_NPA                    =                    ((new_NPA_ratio*100)-
perceived_new_NPA's)/t_for_new_NPA_growth

t_for_new_NPA_growth = 3
```

The perceived level of *new NPA ratio* leads to a policy judgement the necessity for corrective action in tightening credit policy. This represents a political goal setting process of the decision agents and is an example of bounded rationality. It shows that perceptions and cognitive biases play a role in forming the premise for decision-making. An increase in the perceived level of *new NPA ratio* leads to pressure on the decision agents to tighten credit policy. This is operationalised by lowering the threshold fraction of a loan applicant's income that the bank would consider as an appropriate maximum fraction of income for expenditure on debt. Thus, in past years, an individual could spend up to one third of gross income on servicing outstanding debt. In the wake of bad debt write-offs, most banks have reduced this level down to one quarter of the individual's income. In our model, this is represented by the *affordability factor*. The graph of *affordability impact* relates the *perceived new NPA's* to the desired *affordability factor* of the

decision agents. This formulation is non-linear and represents a declining *affordability factor* when *new non-performing advances* increases, describing the pressure on decision agents to tighten credit policies when there is an increasing trend in defaulting loans.

Figure 3.9

Perceived new NPA's versus affordability impact
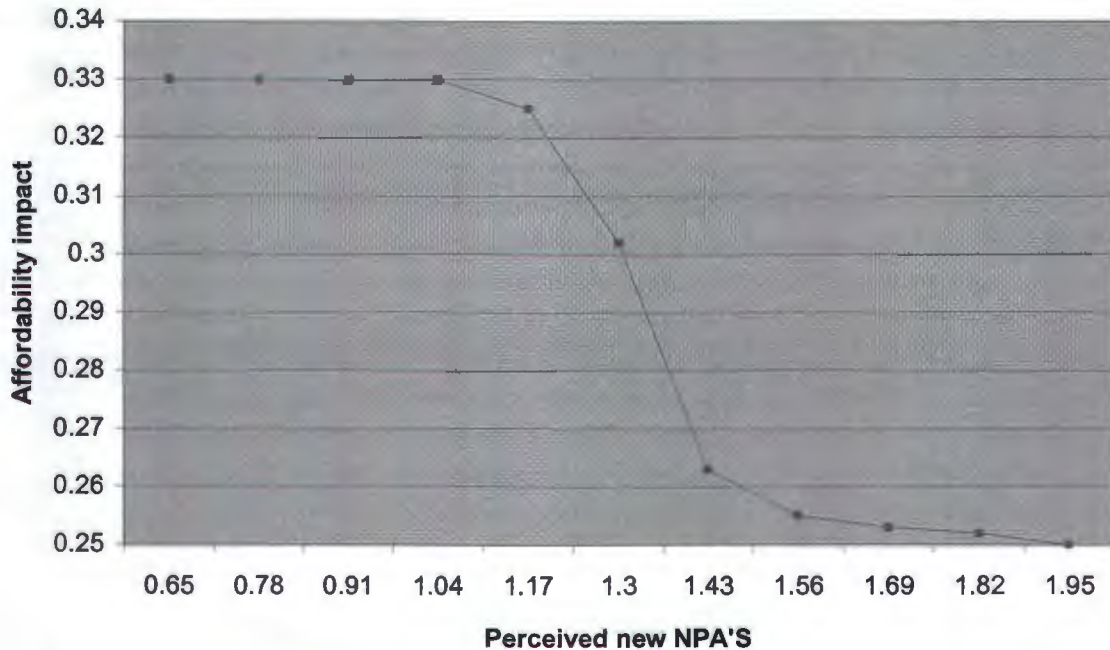
The above graph is described in Cartesian notation:

affordability_impact = GRAPH(perceived_new_NPA's)
(0.65, 0.33), (0.78, 0.33), (0.91, 0.33), (1.04, 0.33), (1.17, 0.325), (1.3, 0.302), (1.43, 0.263), (1.56, 0.255), (1.69, 0.253), (1.82, 0.252), (1.95, 0.25)

The *affordability factor* is applied to all new loan applications. The adjustment to loans granted is conceptualised as an accumulating stock with an adjustment time, reflecting the time required for the decision agents to adjust their perception of the appropriate affordability level to apply. Two adjustment times apply dependent on the direction of the trend in perceived new non-performing advances; a positive trend implies increasing default rate for the bank and will lead to a rapid response in lowering the affordability factor, a negative trend in perceived new non-performing advances ratio will not necessarily lead to a rapid increase in affordability factor. This reflects the observed conservative bias in the credit organization; once a rapid increase in default rate has been experienced and the decision agents have tightened their credit policies, they are loath to loosen the reigns once the default rate has returned to previously normal levels.

affordability_factor(t) = affordability_factor(t - dt) + (delta_afford_factor) * dt

INIT affordability_factor = 0.33

delta_afford_factor = (affordability_impact-affordability_factor)/t_for_afford_factor

t_for_afford_factor = IF(TREND(affordability_factor,2,0)<0)THEN(2)ELSE(2000)

A consequence of a lower *affordability factor* is a lower rate of acceptance of new loan applications. This is illustrated in Figure 3.10.

Figure 3.10

Affordability factor versus acceptance rate
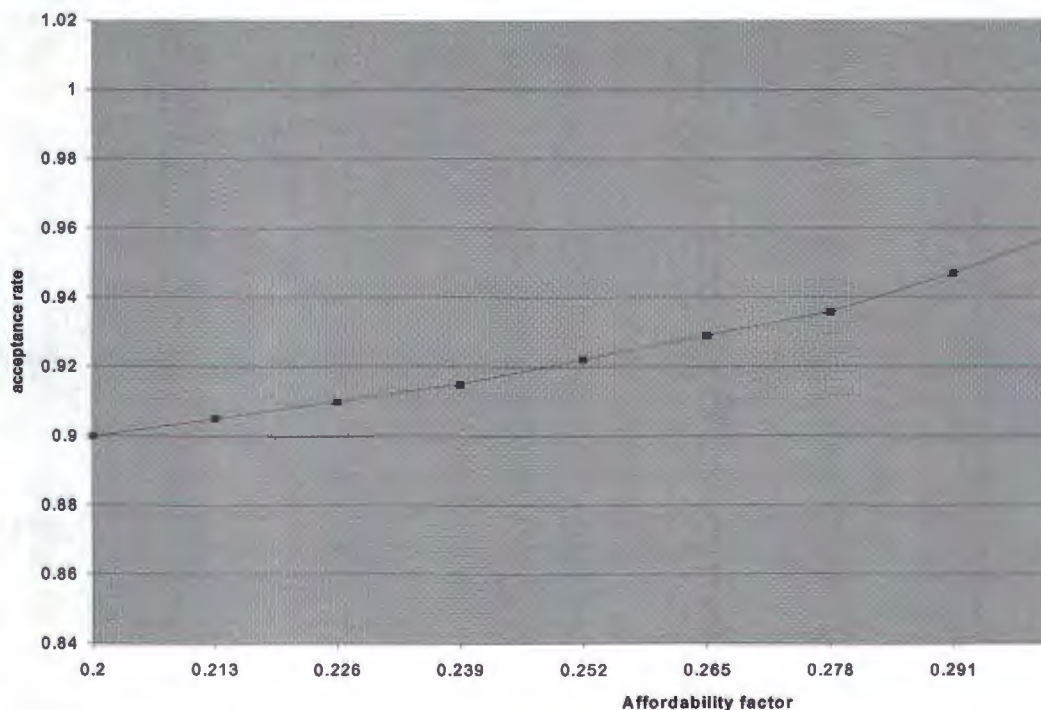
acceptance_rate = GRAPH(affordability_factor)
(0.2, 0.9), (0.213, 0.905), (0.226, 0.91), (0.239, 0.915), (0.252, 0.922), (0.265, 0.929), (0.278, 0.936), (0.291, 0.947), (0.304, 0.96), (0.317, 0.976), (0.33, 1.00)

The impact of this loop is to depress the acceptance of new loans under adverse conditions of high defaulting loan repayments in an effort to accept less risky business so as to reduce the rate of *new non performing advances*. This closes the first feedback loop.

We now continue by considering the second loop in the credit process. The stock of *performing advances* represents the historic loans granted at a historic level of affordability factor. This historic level of affordability is represented by the stock *historic affordability*. A characteristic of all stocks is explicit here; that a stock has a "memory", it retains a continuity from the past to the present in the level of the stock [Forrester: 1961]. The current level of the *historic affordability* is an average of the past level of current *affordability factor*. This level is slowly modified at the new current level of *affordability factor*, slowly adapting the historic level of affordability as new loans are written.

---

historic_affordability(t) = historic_affordability(t - dt) + (delta_historic_afford) * dt

INIT historic_affordability = 0.3

delta_historic_afford = (affordability_impact-historic_affordability)/ave_loan_duration

ave_loan_duration = 84

The *historic affordability* also plays a further, subtle role. It is also used here as an indicator of the quality of the loan book. The quality of the loan book determines the rate at which clients default and thus the rate at which *new non performing advances* are generated. The decision agents face a trade-off; prosperity is usually associated with growth conditions, therefore the dominant logic is to achieve growth in advances. However, the higher the rate of growth, the lower the quality of loans taken on board. Thus there is a trade-off between growth in advances and quality of loans that may impact on the rate of *new non-performing advances* some time in the future.

Before establishing an equation for this relationship between *historic affordability* and *annual default rate*, we must first discuss the drivers of default.

We can always expect some minimum level of rate of default. This is because the individuals that have taken loans are not all homogenous in characteristics. Some are wealthier than others; some will experience events that force them into a situation where they will default on their repayments, for example through job retrenchments, etc. The minimum value will depend, however, on the quality of the loan book that, to some extent, determines the ability of the average client to absorb periods of financial difficulty. A very wealthy client base is likely to have a much lower default rate than a client base of very limited wealth because of their ability to carry themselves during times of financial difficulty.

The second driver of default rate is the level of interest rate on advances. Loans are approved for clients given their ability to service the debt at the interest rate on advances at the time of applying for the loan. A large increase in interest rate on advances significantly increases the debt burden that loan holders face. An increase in required repayments may push some individuals over the brink, resulting in increasing default rates. The higher the level that the rate on advances reaches, the greater the level of default that can be expected.

Based on the above conceptualisation, a formulation for the rate of default is developed here. Referring to Figure 3.11, the curve of *annual default rate* should be starting at some minimum level and climbing more and more steeply as the *rate on advances* increases.

Figure 3.11

Affordability factor versus annual default rate
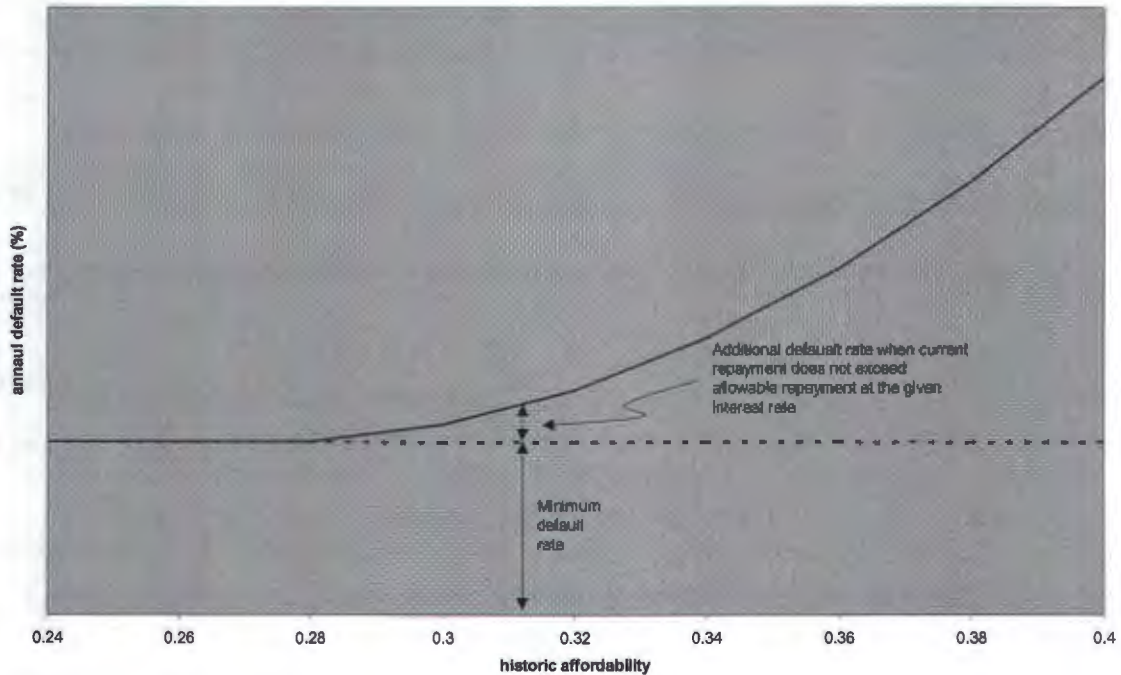
The following equation is of the form that would meet these requirements.

impending_default = min_default+ave_default*debt_stress_multiplier

Thus the *impending default* rate is a function of the *minimum default* rate and the *average default* rate multiplied by a *debt stress multiplier*. Each factor is defined in greater detail below:

Minimum default:
The *min default* is a function of the *historic affordability*. This relationship is shown in Figure 3.12. The graph is described in Cartesian notation below.

min_default = GRAPH(historic_affordability)
(0.25, 0.250), (0.258, 0.250), (0.266, 0.255), (0.274, 0.260), (0.282, 0.267), (0.29, 0.274), (0.298, 0.280), (0.306, 0.288), (0.314, 0.295), (0.322, 0.30), (0.33, 0.30)

Figure 3.12

Minimum default versus historic affordability
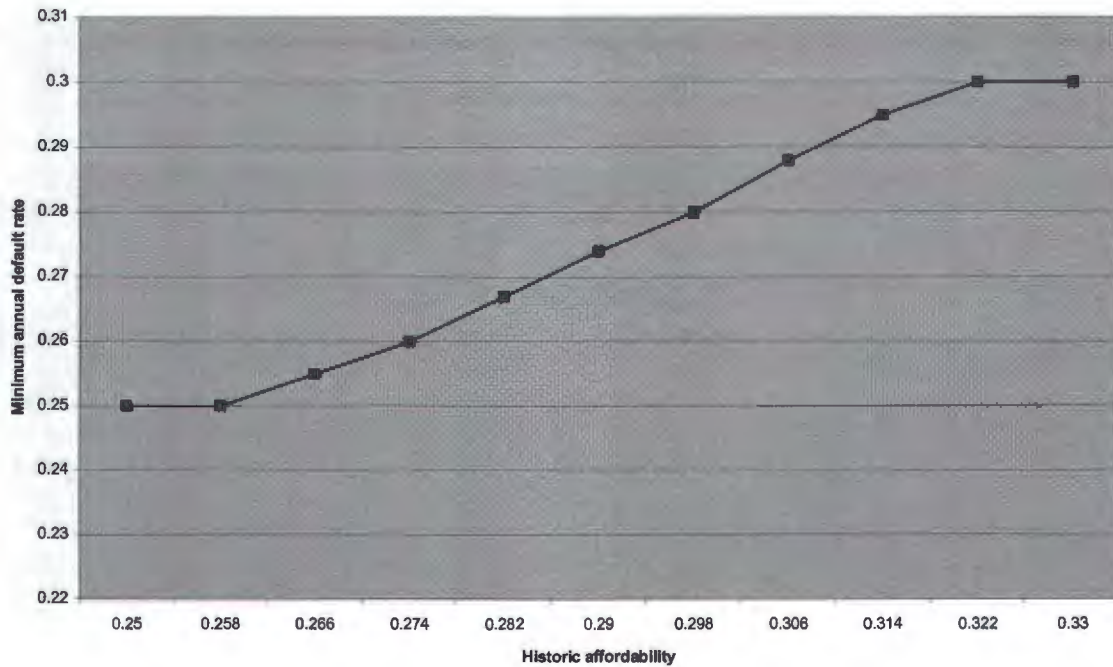
Average default:
The *ave default* is the additional default rate over and above the minimum default rate at a normal operating level. This is taken as at 1985 at a rate on advances of 14%.

ave_default = 1 (percent per annum)

Debt stress multiplier:
The *debt stress multiplier* is a function of the ratio of *ave current repayments* to the maximum desired repayment (*max desired repay)*.

The relationship between the *debt stress multiplier* and the ratio of *ave current repayment* to *max desired repay* is illustrated in Figure 3.13.

The relationship is given in Cartesian notation below:

debt_stress_multiplier = GRAPH(repayment_ratio)
(0.00, 0.00), (0.05, 0.00), (0.1, 0.045), (0.15, 0.09), (0.2, 0.075), (0.25, 0.09), (0.3, 0.09),
(0.35, 0.09), (0.4, 0.105), (0.45, 0.12), (0.5, 0.135), (0.55, 0.15), (0.6, 0.165), (0.65, 0.27),
(0.7, 0.57), (0.75, 0.99), (0.8, 1.86), (0.85, 3.18), (0.9, 4.98), (0.95, 7.30), (1.00, 10.0)

Figure 3.13

Stress multiplier versus ratio of repayments
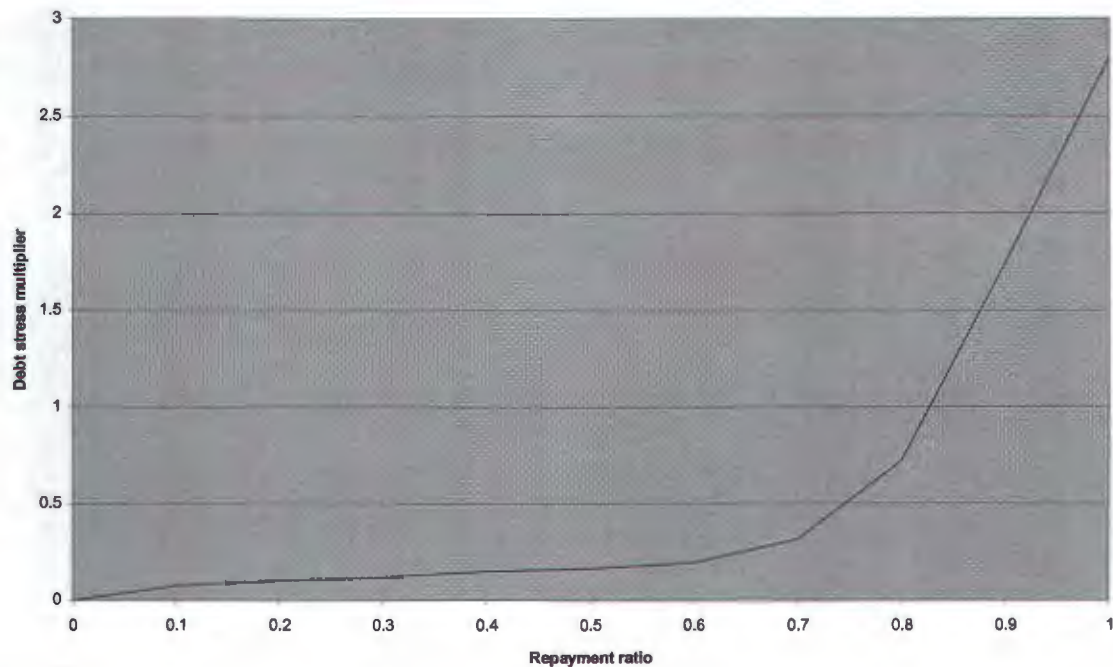
The *debt stress multiplier* modifies the *impending default* rate in response to changes in the repayment levels of the loan holders. The ratio of *ave current repayment* and *max desirable repay* represents an average affordability measure.

Maximum desired repayment:
The desired repayment is based on the average gross salary of the client segment and the *prudence factor* for the loan book as an aggregate entity. The prudence factor is an absolute measure against which to measure the maximum desired repayment.

max_desired_repay = ave_gross_salary*prudence_factor

prudence_factor = 0.3

The average current repayment:
The *ave current repayment* is calculated as loan amortization problem involving the future payments whose present value at the loan interest rate (*rate on advances*) equals the amount of the average outstanding loan size at the current average outstanding term on the loan (*ave outstanding loan term*) [Gitman: 1988].

```
ave_current_repayment =
ave_loan_size/((((1+(rate_on_advances/1200))^ave_outstanding_loan_term)-
1)/((rate_on_advances/1200)*(1+(rate_on_advances/1200))^ave_outstanding_loan_ter
m))
```

When the ratio of current to desired repayment has a value of 1, it implies that the ratio is at the 1985 impending rate of default for a rate on advances of 14% - a base value. This yields 1 as the value for debt stress. The shape of the curve on the right had-side of the unity point reflects our belief of how the debt stress escalates as the ratio rises. Thus, when the ratio exceeds a value of 1, the debt stress rises quickly as it becomes increasingly difficult for the average loan holder to service his debt at this rate of repayment for an extended period of time. A debt stress level of one represents a threshold level. A ratio of less than one results in a multiplier impact of less than one implying a reducing level of stress.

The *impending default* rate represents the default rate that exists instantaneously at a given point in time. An escalation in the *rate of advances* will, for example, instantaneously increase the *impending default rate*. However, the statistics indicate that the default rate does not exhibit a sudden step increase in when a step increase in *rate on advances* is experienced. Rather, a delay occurs between peak values of interest rate and peak values of default rate.

The dynamic behaviour of the *annual default rate* is represented by a self-adjusting stock with a first-order negative feedback loop controlling the dynamics of the default rate. The feedback loop from the *annual default rate* to the flow adjusting the default rate is an equilibrium seeking self adjusting process. The rate at which the *annual default rate* adjusts to a change in the *impending default rate* is a function of the coefficient *time for default*. This coefficient controls the rate at which the *annual default rate* changes given a change in input. The *annual default rate* is the driving variable for the flow of *new non-performing advances* that depletes the stock of *performing advances*.

```
annual_default_rate(t) = annual_default_rate(t - dt) + (delta_default) * dt

INIT annual_default_rate = impending_default

delta_default = (impending_default-annual_default_rate)/t_for_default

t_for_default = 1
```

This completes the second negative feedback loop that aims to control the development of the *historic affordability*, and therefore also the quality, of the loan client base. This loop is a negative feedback loop that seeks to restore balance when there is a deviation in the system behaviour by seeking a lower future *annual default rate*. It is a natural response to

the realisation of the decision agents that the credit tightness is at insufficient levels to ensure sound future performance.

3.3.5. The Deposit Book Accumulation

Figure 3.14 illustrates the stock and flows that affect the accumulation of the deposits book (*retail deposits*). *Retail deposits* is a stock variable that is increased by the Rand value of *new deposits* that represents the monthly rate at which new deposits are placed at the bank. *Retail deposits* are decreased by *withdrawals* of deposits by depositors.

New deposits, the inflow that increases the stock of *retail deposits*, is an exogenous variable. *Deposits growth* is a function of the market demand and interest rates. The development of the *deposits growth* is beyond the scope and aims of this research (and beyond the boundary of the model) and is provided as an exogenous input into the model.

Figure 3.14

Deposits resource system
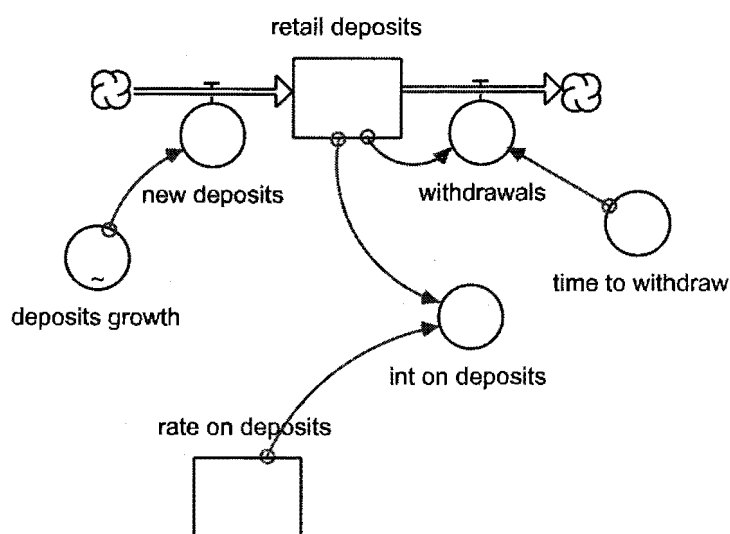
Deposits growth is based on the historic advances as experienced over the period 1 April 1995 to 31 March 2000. The growth in deposits is described by the relationship below using Cartesian co-ordinates. The *x* co-ordinates represent time periods in months starting from time period 1 at 1 March 1995.

deposits_growth = GRAPH(TIME)
(1.00, 2.7e+009), (3.57, 2.8e+009), (6.13, 2.9e+009), (8.70, 2.9e+009), (11.3, 3e+009), (13.8, 3.1e+009), (16.4, 3.2e+009), (19.0, 3.2e+009), (21.5, 3.3e+009), (24.1, 3.4e+009), (26.7, 3.5e+009), (29.2, 3.6e+009), (31.8, 3.7e+009), (34.3, 3.7e+009), (36.9, 3.8e+009), (39.5, 3.5e+009), (42.0, 3.2e+009), (44.6, 3.1e+009), (47.2, 3.1e+009), (49.7, 3.2e+009), (52.3, 3.3e+009), (54.9, 3.5e+009), (57.4, 3.8e+009), (60.0, 4.2e+009)

The rate of outflow *withdrawals* is governed by a feedback loop that creates the rate of withdrawals that depletes the stock of *retail deposits*. This is a first-order negative feedback loop that generates typical equilibrium seeking behaviour. In the absence of any new inflows, the negative feedback loop would cause the *retail deposits* resource to decline towards zero in an exponentially decaying mode of behaviour. The rate at which the outflow *withdrawals* depletes the stock of *retail deposits* is a function of the value for the coefficient *time to withdraw*. This coefficient represents the average period that elapses before a deposit is withdrawn. The average period for the aggregate stock of deposits is 18 months.

The ithink equations follow:

deposits(t) = deposits(t - dt) + (new_deposits - withdrawal) * dt

INIT deposits = 40.142e009

new_deposits = deposits_growth

withdrawal = deposits / time_to_withdraw

time_to_withdraw = 18

Interest paid on deposits (*int on deposits*) is a function of the size of the deposits book and the *rate on deposits*.

---

interest_paid_on_deposits = (deposits)*rate_on_deposits/1200

It is interesting to note the advances book has a much higher value than the deposits book. Yet, the rate at which monthly deposits are placed at the bank far exceeds the monthly rate of new advances being generated. To many, this may seem counter-intuitive. The reason for this apparent anomaly can be easily understood by inspecting the stock and flow diagrams of the *performing advances* and *retail deposits* book. The average duration of a deposit is far less than the average duration of a loan. This results in a far greater outflow rate of withdrawals from the deposit book than of repayments from the advances book. The net result is that the deposits book does not accumulate the necessary mass to surpass the size of the advances book.

Since deposits are used as a source of funding for advances, the shortfall of deposits over advances requires the bank to obtain funds in the money markets. This aspect is a key one but will be returned to in detail later on in this chapter after other important aspects impacting on funding have first been discussed.

3.3.6. Liquid Asset Accumulation

Banks accept deposits from depositors and make advances to lenders using the depositor's funds. A difficulty arises when depositors wish to withdraw their funds. Adequate liquidity assures depositors that they can withdraw their funds. To ensure adequate liquidity the regulatory authorities set a specific target for cash and liquid assets as a fraction of liabilities held. Thus the monetary authorities require banks to hold a certain proportion of their deposits in non-interest bearing balances with the Reserve Bank. These reserves are callable from the Reserve Bank to meet withdrawals in the event of a liquidity crisis. This retains depositor's confidence in the bank and prevents a "run" on the bank. Figure 3.15 illustrates the stock of *liquid assets*.

Figure 3.15

Liquid asset resource accumulation
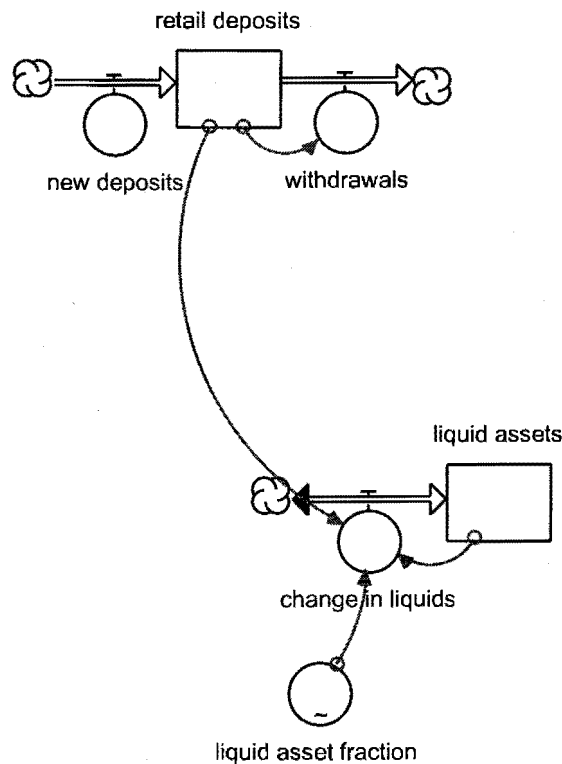
The accumulation of *liquid assets* is represented by a self-adjusting stock with a first-order negative feedback loop controlling the dynamics of the *liquid assets*. The feedback loop from the *liquid assets* stock to the flow adjusting the change in *liquid assets* is an equilibrium seeking self-adjusting process. The value of the *liquid assets* to be held is a function of the value of the *retail deposit* book and the statutory *liquid asset fraction*.

```
liquid_assets(t) = liquid_assets(t - dt) + (change_in_liquids) * dt

INIT liquid_assets = 2681.4e006

change_in_liquids = (deposits * liquid_asset_fraction) - liquid_assets
```

The *liquid asset fraction* corresponds to the actual liquid asset fraction carried by the bank over the time period of the investigation.

```
liquid_asset_fraction = GRAPH(TIME)

(1.00, 0.105), (6.90, 0.105), (12.8, 0.11), (18.7, 0.15), (24.6, 0.15), (30.5, 0.105), (36.4, 0.105), (42.3, 0.105), (48.2, 0.11), (54.1, 0.11), (60.0, 0.11)
```

Liquidity problems are the consequence of several possible events; economic slumps or the failure of other financial institutions, cash flow difficulties due to non-performing loans and bad debts, interest rate mismatching with negative consequences during interest rate shifts or over reliance on a single source of funds. Adequate liquidity also protects shareholders against the forced sale of assets to meet liquidity requirements under adverse conditions.

Holding liquids at the central bank impacts negatively upon profitability because liquid assets tend to yield a return below the bank's cost of funds.

3.3.7. Capital Accumulation

Modern deposit-taking institutions are required to keep a substantial portion of their assets in non-interest bearing reserves at the reserve bank. The role of capital is to act as a buffer against unidentified future losses. The amount of reserves to be held by any particular bank is determined by the riskiness of its asset portfolio and provides a "safety net" to ensure sufficient liquidity to enable the financial institution to pay depositors on demand.

The Basle Accord uses a two-tier concept to define the capital of a bank; Tier One consists of share capital and disclosed reserves, Tier Two consists of items such as hidden reserves, unrealised gains on investment securities and medium to long-term subordinated debt [Matten: 1996]. Tier Two capital may not exceed Tier One capital so that up to 50% of capital can be financed by items such as subordinated debt. The Tier Two capital provides bank executives with the ability to adjust the total capital holding far more rapidly than with Tier One capital – a necessity when capital exceeds the number of projects to invest in resulting in reduced return on capital ratios.

Figure 3.16 illustrates the stock accumulations of Tier One and Tier Two capital.

Figure 3.16

Tier 1 and Tier 2 capital formations
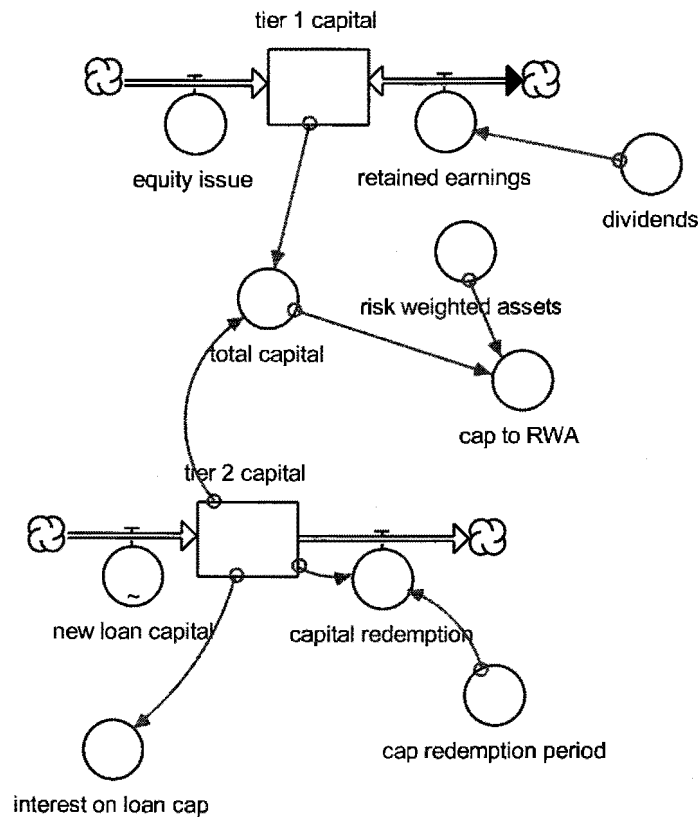
Tier 1 capital is increased by two flows; an inflow of *equity issued* and, an inflow of *retained earnings*. The *retained earnings* is depicted as a bi-flow representing the possibility of a positive inflow when the bank produces a profit and the possibility of an outflow of *Tier 1 capital* if the bank records a loss.

tier_1_capital(t) = tier_1_capital(t - dt) + (equity_issue + retained_earnings) * dt

INIT tier_1_capital = 2172.9e006

equity_issue = 0

retained_earnings = net_income_after_tax-dividends

Tier 2 capital is increased by the inflow of *new loan capital* and is decreased by the outflow of *capital redemption*. The rate of outflow of *capital redemption* is governed by a first-order negative feedback loop that depletes the stock of *Tier 2 capital*. This feedback loop generates equilibrium-seeking behaviour that, in the absence of any new inflows, would

result in the *Tier 2 capital* declining towards zero in an exponentially decaying mode of behaviour. This replicates the ongoing redemption of capital loans as time progresses. The value of the outflow is a function of the value of the *Tier 2 capital* stock and the coefficient *capital redemption period*. This coefficient represents the average period that the *Tier 2 capital* is held before redemption occurs.

---

tier_2_capital(t) = tier_2_capital(t - dt) + (new_loan_capital - capital_redemption) * dt

INIT tier_2_capital = 547.1e006

new_loan_capital = GRAPH(TIME)

(1.00, 1.5e+007), (6.90, 1.5e+007), (12.8, 1.5e+007), (18.7, 3.8e+007), (24.6, 3.8e+007), (30.5, 3.8e+007), (36.4, 5e+007), (42.3, 5e+007), (48.2, 4.9e+007), (54.1, 3.9e+007), (60.0, 3.9e+007)

capital_redemption = tier_2_capital/cap_redemption_period

The minimum amount of capital to be held is prescribed in the Basle Accord as a target of 8% of risk-weighted assets [Matten: 1996]. This has recently (2002) been raised to 10%. Each class of asset draws a reserve requirement in accordance to its riskiness. The riskier the asset (higher risk of default) the higher the reserve requirement. Any amount held above 8% improves the standing of the bank from a risk perspective but will reduce the return-on-capital which may not find favour with the shareholders. A bank with a capital adequacy that is below 8% risks having a poor credit rating with credit agencies resulting in higher cost of funding when borrowing funds from institutions. The capital adequacy is calculated in the model as follows:

---

total_capital = tier_1_capital+tier_2_capital

risk_weighted_assets = total_advances*0.5

capital adequacy = total_capital/risk_weighted_assets

For the purposes of this model, the risk weighting is taken as an average of 50%. This is due to the high levels of mortgage loans that attract a 50% risk weighting.

3.3.8. Fixed Investment Accumulation

Traditional banks are very capital intensive operations. Investment in infrastructure and technology usurp large amounts of cash. Figure 3.17 illustrates the *book value of fixed assets* that is increased by the inflow of *investment in fixed assets* and is decreased *depreciation*.

_____ **Figure 3.17**

Fixed investment accumulations

book value of fixed assets

investment in fixed assets   depreciation

depreciation period
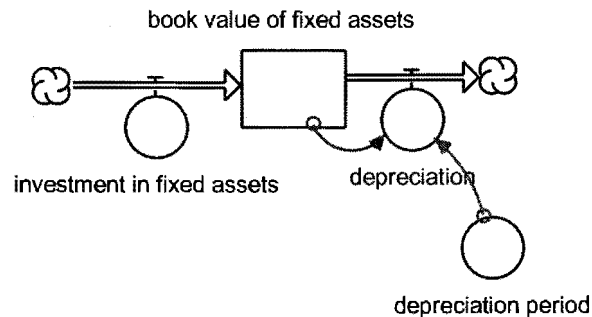
Depreciation is modelled as the *book value of fixed assets* divided by the *depreciation period* that represents the time to depreciate the fixed assets. Five years is the approximate estimated depreciation period for the aggregate stock of fixed assets. A more detailed model may contain individual asset types and values for each different fixed asset category. This method of representing depreciation approximates straight-line depreciation for a company that replaces assets as they depreciate.

---

book_value_of_fixed_assets(t) = book_value_of_fixed_assets(t - dt) + (investment_in_fixed_assets - depreciation) * dt

INIT book_value_of_fixed_assets = 278.4e006 (Rand)

investment_in_fixed_assets = 10e006 (Rand per month)

depreciation = book_value_of_fixed_assets/depreciation_period

depreciation_period = 60 (months)

3.3.9. The Funding Resource

The stock of *funding* represents the amount of funding required to keep the bank liquid when asset creation exceeds deposit taking. The treasury function of the bank sources the funds in the money market to cover the needs of the bank. In addition to the shortfall of advances over deposits, the funding calculation also includes the surplus or shortage of

cash from operations. Effectively, the funding pool acts as a cash management function. The monthly cash requirement is calculated as:

change_in_funding_required = new_advances-repayments_and_settlement-recoveries-new_deposits+withdrawal-net_interest_received_monthly+tax+other_expenses-non_interest_income+investment_in_fixed_assets+dividends-equity_issue+change_in_liquids-new_loan_capital+capital_redemption

The monthly funding requirement is increased by outflows of cash and is reduced by cash inflows. Figure 3.18 illustrates the stock of *funding* represented as a self-adjusting stock. The value of *funding* is adjusted on a monthly basis by adding or subtracting the *change in funding required* to the *funding* stock.

Figure 3.18

Accumulation of the funding resource
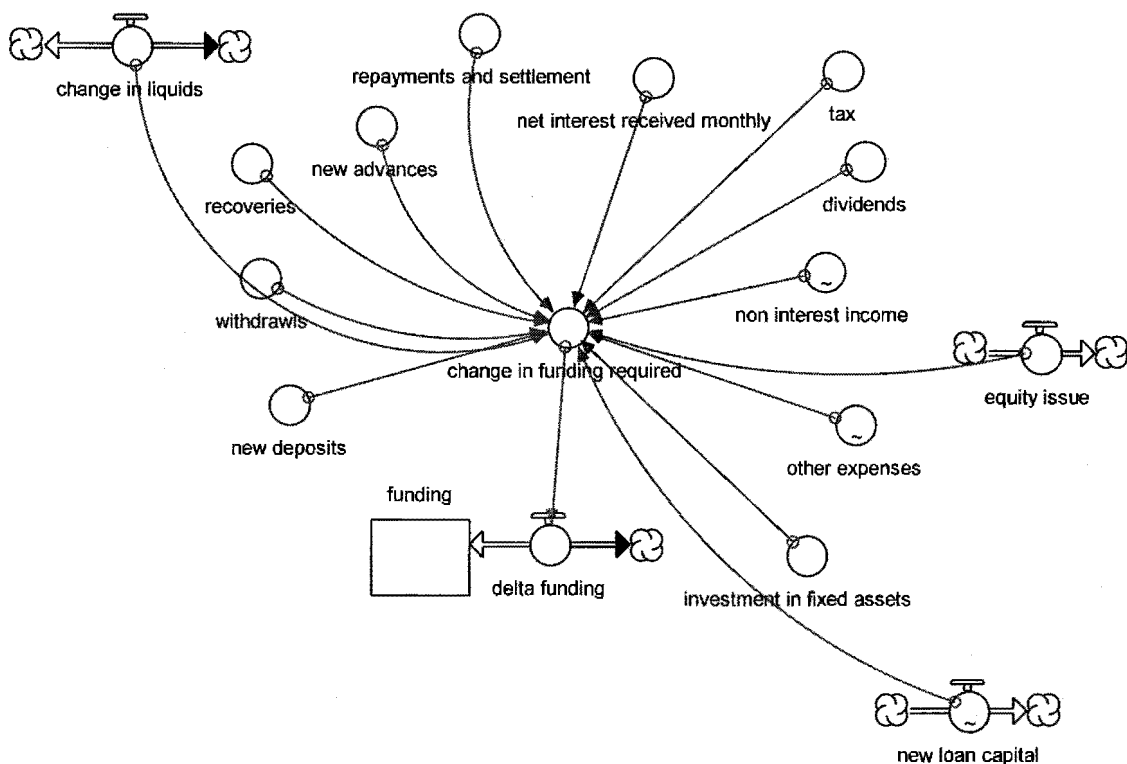
funding(t) = funding(t - dt) + (delta_funding) * dt

INIT funding = 14.269e009

delta_funding = change_in_funding_required

3.3.10. The Financial Flows

The financial flows are a consequence of the resource accumulations of the interest income generation system. Thus, the financial flows are a direct consequence of the state of the key stock accumulations. The stock accumulations and rates of flow represent the substance of the business; the financials are the speedometer of the business "hanging off" the side of the resource structure [Warren: 2000]. The financial flows alter the state of the resource accumulations bringing the resource structure to a new state.

Two different financial perspectives and influences are present in the interest income generation system; a cash flow perspective and an accounting perspective. The cash flow perspective considers the timing of financial flows whereas the accounting perspective considers the statutory financial reporting requirements.

Figure 3.19 shows how the cash and accounting flows relate to one another. Starting on he left-hand-side of Figure 3.19, *interest received* is a function of the stock of *performing advances* and the *rate on advances*.

---

interest_received = performing_advances*rate_on_advances/1200

rate_on_advances(t) = rate_on_advances(t - dt)

INIT rate_on_advances = 14 (%)

This represents a cash flow of actual monthly interest received. Interest paid (*int paid*) is made up of three elements; interest paid on deposits (*int paid on deposits*), interest paid on funding (*int paid on funding*) and interest paid on loan capital *(int paid on loan cap)*.

---

int_paid = int_paid_on_deposits+int_paid_on_funding+int_paid_on_loan_cap

int_paid_on_deposits = (retail_deposits-cash_on_hand)*rate_on_deposits/1200

int_paid_on_funding = funding*funding_rate/1200

int_paid_on_loan_cap = tier_2_capital*loan_cap_rate/1200

loan_cap_rate = 11

Interest received nets off against *int paid* to determine *net interest received monthly*. This is a physical cash flow that affects *funding*. Net interest received is thus depicted in the funding sector rather than the financial sector.

```
net_interest_received_monthly = interest_received-int_paid
```

The *net interest received monthly* impacts on the *change in funding required* that in turn is a key driver for the size of the *funding* stock. However, since the state of the *funding* stock has adjusted due to the cash flows, the amount of interest paid on the funding is also again affected (see financial sector), thus closing the feedback loop on itself.

Accounting (information) flows are taking place simultaneously with the physical cash flows. The *interest income* (financial sector), an accounting equation, is determined by the *rate on advances* and the *total advances*. *Total advances* includes *performing advances* plus *non-performing advances*. Thus, even though no physical payments may be received on the stock of *non-performing advances*, the interest is still earned by the bank.

```
interest_income = total_advances*rate_on_advances/1200

total_advances = non_performing_advances+performing_advances
```

Net interest income is an accounting equation that offsets the *interest income* against the *int paid*.

```
net_interest_income = interest_income-int_paid
```

Total income is the sum of *net interest income* and *non-interest income*. Since this research has focused on *interest income*, the *non-interest income* is provided as an exogenous input. The value of the *non-interest income* is based on the actual accounting figures as reported in the bank's financial figures.

```
Total_income = net_interest_income+(non_interest_income)
```

Operating income is the net result of the bank's *total income* less *bad and doubtful advances*. *Bad and doubtful advances* is a function of the size of the *non-performing advances* stock and the rate at which the bank chooses to write-off *non-performing advances*, i.e. the bank's write-off policy – the *time to write off*. In addition, this operating division received *profit share* from other divisions as a result of it's interest in other activities. This is incorporated into the model as an exogenous input and is included here for completeness only.

```
operating_income = total_income-bad_&_doubtful_advances+prof_share
```

Net income before tax is the result of the *operating income* less the *operating expenses*. *Operating expenses* is the sum of *depreciation* of fixed investments and the other operating expenses (*other expenses*). *Other expenses* is shown as an exogenous input and is driven by the cost of operations including salaries, technology infrastructure costs and similar expenses. *Other expenses* reflect the historic expenses as shown in the income statement of the bank over the simulation time horizon.

```
net_income_before_tax = operating_income-operating_expenses
```

Net income after tax is the consequence of *net income before tax* and the *tax* paid.

```
net_income_after_tax = net_income_before_tax-tax

tax = IF(net_income_before_tax<=0)THEN(0)
ELSE(net_income_before_tax*tax_rate/100)

tax_rate = 43+step(-3,12)+step(-5,24)+step(-5,48)
```

Net income after tax is distributed as *dividends* to shareholders and the balance is retained as *retained earnings* (capital sector), adding to the *Tier1 capital* base of the bank. The policy of the bank was to pay a dividend of 30% of the *net income after tax*. Dividends are only declared if a profit after tax has been made.

```
retained_earnings = net_income_after_tax-dividends

dividends =
IF(net_income_after_tax>0)THEN(net_income_after_tax*dividend_policy)
ELSE(0)

dividend_policy =0.3
```

Figure 3.19

The financial flows
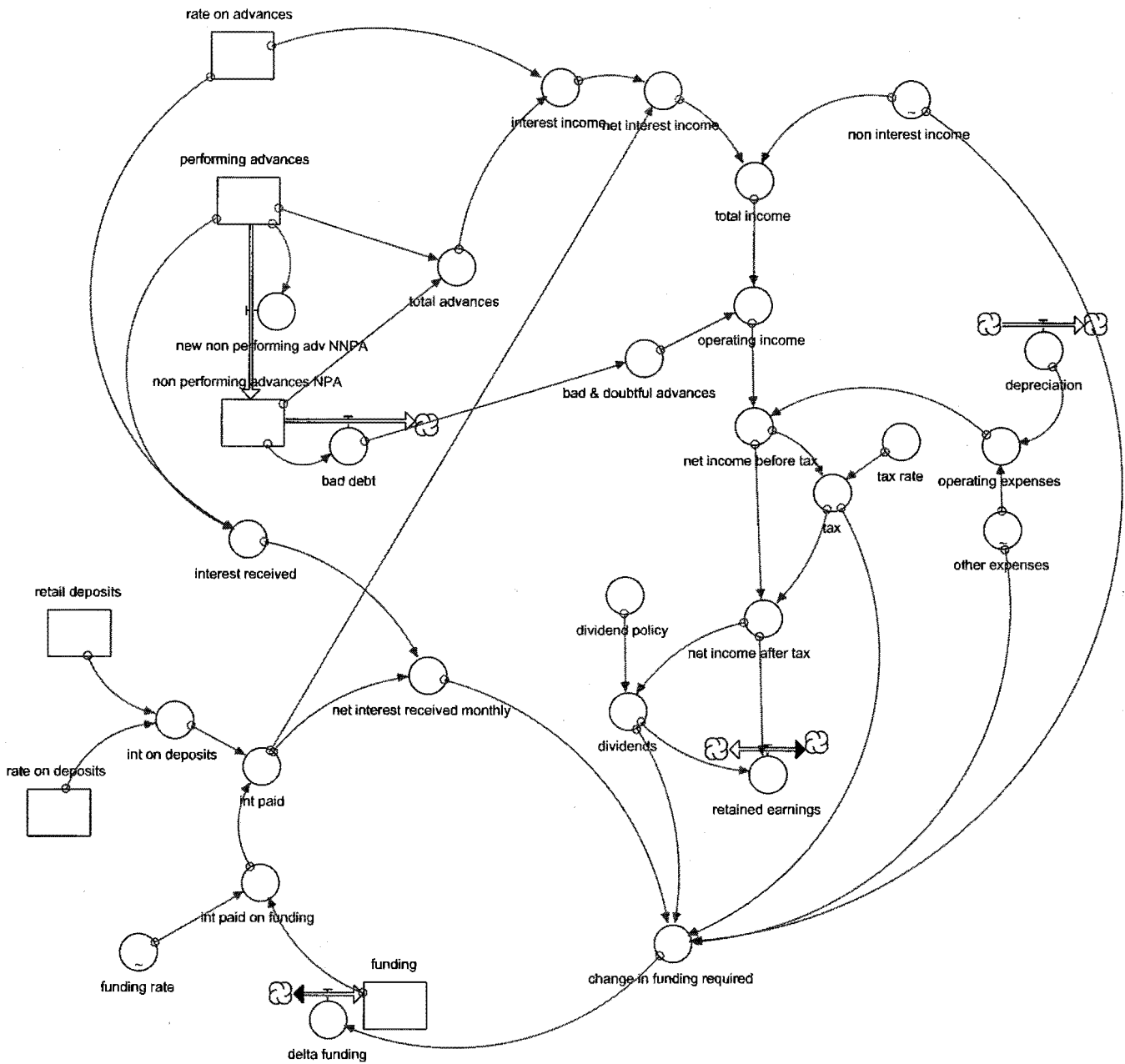
3.3.11. Interest rates

Having completed the bulk of the model description, the final outstanding elements are the interest rates. Here we have two sectors: the market rates sector and the bank rates sector.

The market rates sector contains the single variable *market rates*. *Market rates* is an exogenous input that reflects the market price at which the bank can attain its composite

funding pool. This rate drives the *funding rate*, *rate on deposits* and the *rate on advances* with different time delays between the movements of these rates.

Figure 3.20

Interest rate structure
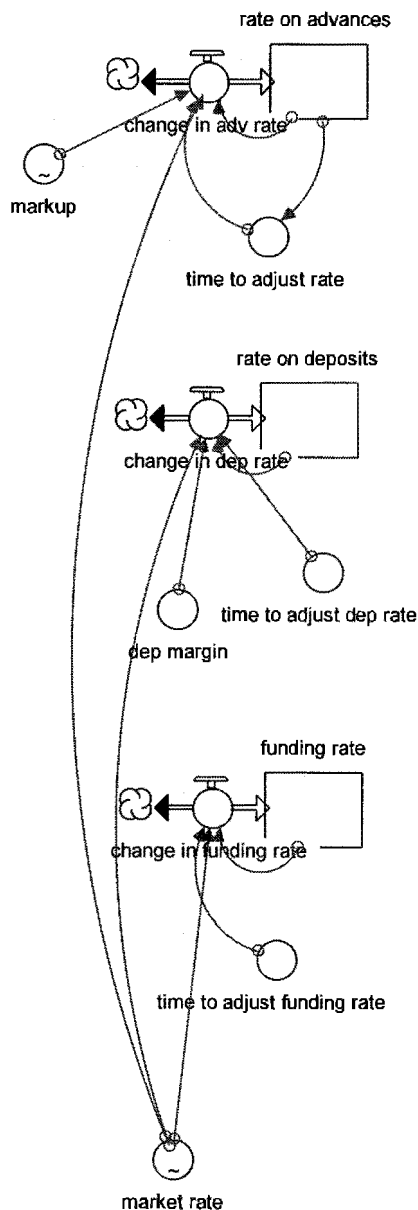
The interest rates namely the *funding rate*, *rate on deposits* and *rate on advances* were modelled as self-adjusting stocks to replicate the behavioural delays in adjustment time between these rates. For the purposes of this model, the *rate on advances* was set to re-adjust first in reaction to movement in the *market rate*, followed by the *rate on deposits*. Finally, the *funding rate* would adjust. This replicates the situation that the retail bank found themselves in during the volatile interest rate period of the late 1990's. This aspect is discussed in detail in Chapter 5. The model is set to allow for dynamically varying delays.

The *market rate* is described by the Cartesian coordinates:

market_rate = GRAPH(TIME)
(1.00, 13.7), (2.00, 13.9), (3.00, 13.9), (4.00, 14.2), (5.00, 14.4), (6.00, 14.4), (7.00, 14.5),
(8.00, 14.5), (9.00, 14.7), (10.0, 14.6), (11.0, 14.5), (12.0, 14.5), (13.0, 14.4), (14.0, 15.0),
(15.0, 15.4), (16.0, 15.4), (17.0, 15.7), (18.0, 15.6), (19.0, 15.6), (20.0, 16.1), (21.0, 16.5),
(22.0, 16.5), (23.0, 16.3), (24.0, 16.3), (25.0, 16.4), (26.0, 16.3), (27.0, 16.2), (28.0, 16.0),
(29.0, 15.9), (30.0, 15.8), (31.0, 15.5), (32.0, 15.2), (33.0, 15.1), (34.0, 15.0), (35.0, 14.9),
(36.0, 14.5), (37.0, 14.1), (38.0, 14.4), (39.0, 15.4), (40.0, 17.2), (41.0, 18.2), (42.0, 19.0),
(43.0, 18.9), (44.0, 18.7), (45.0, 18.3), (46.0, 17.7), (47.0, 17.3), (48.0, 16.5), (49.0, 15.7),
(50.0, 15.4), (51.0, 15.0), (52.0, 14.2), (53.0, 13.6), (54.0, 13.2), (55.0, 12.4), (56.0, 11.8),
(57.0, 11.7), (58.0, 10.9), (59.0, 10.4), (60.0, 10.4)

Rate on advances is represented by:

rate_on_advances(t) = rate_on_advances(t - dt) + (change_in_adv_rate) * dt

INIT rate_on_advances = 19

change_in_adv_rate = ((market_rate+markup)-rate_on_advances)/time_to_adjust_rate

time_to_adjust_rate =
IF(TREND(rate_on_advances,2,0)*100>=0)THEN(0.25)ELSE(0.1)

markup = GRAPH(TIME)
(1.00, 4.40), (6.90, 4.17), (12.8, 4.08), (18.7, 3.95), (24.6, 3.93), (30.5, 3.93), (36.4, 3.93),
(42.3, 4.00), (48.2, 4.05), (54.1, 3.78), (60.0, 3.78)

The *markup* represents the margin added on to the cost of funding to provide a final price to the customer. The *time to adjust rate* for the *rate on advances* in reaction to a change in market rate is dependent on the direction of movement. In the event of an upward movement in interest rates, the *rate on advances* adjusts more slowly than in the event of a downward trend. This reflects the dominant logic of the decision agents who attempt to maximise margins by delaying the onset of margin squeeze.

The rate on deposits is described by:

rate_on_deposits(t) = rate_on_deposits(t - dt) + (change_in_dep_rate) * dt

INIT rate_on_deposits = 12

change_in_dep_rate = ((market_rate-dep_margin)-rate_on_deposits)/
time_to_adjust_dep_rate

dep_margin = 3.69

time_to_adjust_dep_rate = 0.75

The rate on funding is described by:

```
funding_rate(t) = funding_rate(t - dt) + (change_in_funding_rate) * dt

INIT funding_rate = 13

change_in_funding_rate = (market_rate-funding_rate)/time_to_adjust_funding_rate

time_to_adjust_funding_rate = 1
```

3.4. The Operationalised Resource System

The above systemic resource structure constitutes a dynamic hypothesis and a potential explanation of how financial performance arises from the structure of the resource system of the bank. This constitutes a theory of interest income generation that integrates various aspects of banking and finance theory incorporating causal linkages, resource accumulations, decision policies, and equation formulations for relationships to establish a refutable causal model. Chapter 4 covers the testing of the completeness and coherence of the proposed relationships and theory.

The full model source code is documented in appendix A. In addition to the model described above, the source code includes equations for the calculation of annualised values as well as ratios. The last two mentioned items are not described in this chapter.

Chapter 4

Empirical Validation of the Theory

4.1. Introduction

The scientific goal of highly corroborated theories requires theories with multiple points of contact with reality- that is, multiple points at which a theory can be shown to be incorrect [Bell & Senge:1980]. Although it is impossible to verify that a model represents reality, it is possible and essential to augment our confidence in the theory by undertaking tests at multiple points in an effort to refute the theory and highlight weaknesses. The starting point for this research is the dynamic hypothesis representing a potential explanation of how the structure of the interest income generation system is causing financial performance. The components of the proposed theory are integrated into a single explanatory hypothesis, yet much of the evidence available for the relationships is piecemeal and unobtainable in the form of quantitative data. In testing the integrated dynamic hypothesis, it becomes important to apply a number of validation and verification tests. To address these validation issues, the following tests were undertaken:

- Tests for the consistency of model behaviour (Does the model replicate the observed behaviour)

- Tests for consistency of the model structure. (Does the model behaviour arise for the right reasons)

- Tests for suitability of model behaviour

Whilst Chapters 2 and 3 developed a hypothesis for the interest income generation system, this chapter provides only a small number of points of validation. Thus, the work undertaken here requires far more tests of validation than presented in this work to provide confidence in the conclusions drawn. Thus, this model represents a plausible model but not a fully validated model. Due to time limitations, this work remains outstanding.

4.2. Tests for consistency of model behaviour

Replication of reference modes of behaviour was tested through the model's ability to match the historical reference modes of behaviour. All stocks were initialised to match the historic situation for the bank as at 1 April 1995.

Figure 4.1 illustrates the *funding rate* (an exogenous input) and the accompanying model generated trajectory for *rate on deposits* and *rate on advances*, derivatives of the funding rate. The *funding rate* is based on the actual funding rate as experienced by the bank over the five year time horizon. The significant increase in interest rates during 1998 can clearly be seen on the graph of Figure 4.1.

Figure 4.1

Interest rates
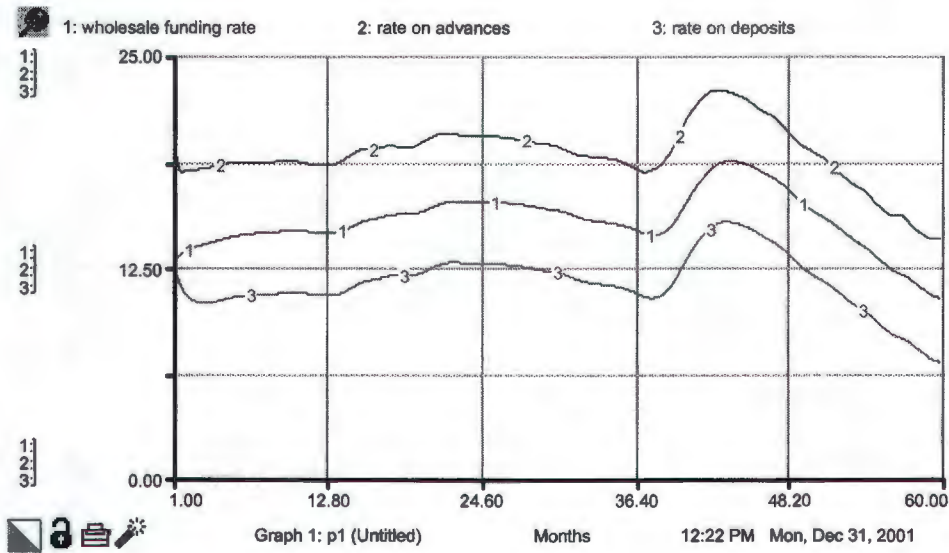
Figure 4.2

Figure 4.2 illustrates the comparative trends for the simulated and actual values for the rate on deposits, rate on advances and funding rate. The value are shown monthly and the time span of the rates extends from August 97 to March 2000 due to the unavailability of earlier funding rate figures.

Interest rate fit
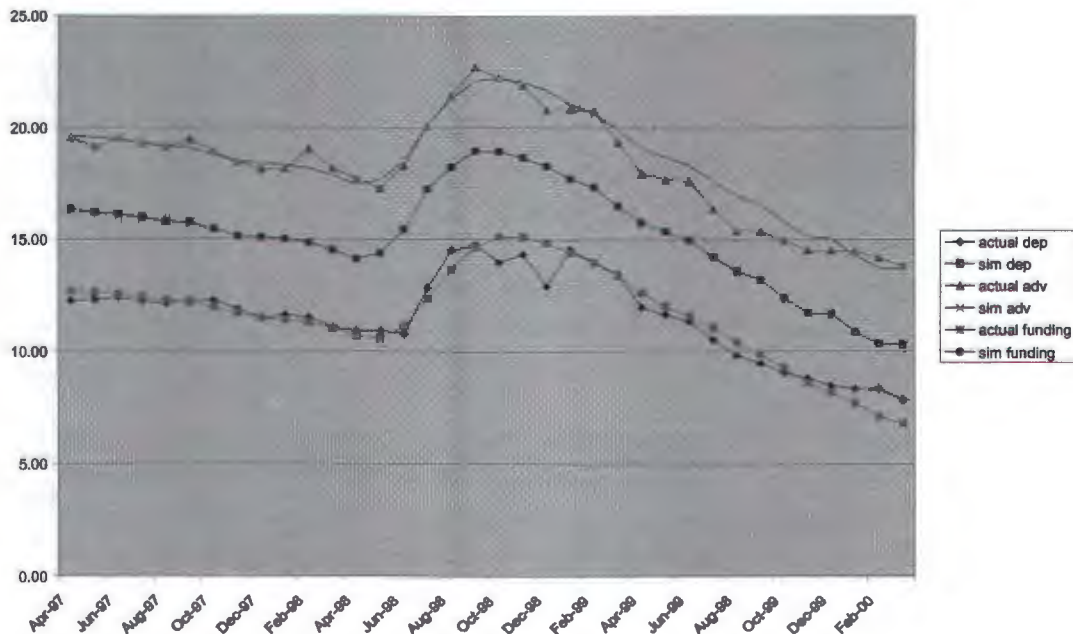
The curves show a reasonable trend-line over the period under review. Since the model is not a forecasting model, the detailed fluctuations of the actual monthly rates are

smoothed into a trend by our model. For the purposes of the research, we are more interested in the broad trends and the response of the system to such trends.

Figure 4.3 illustrates the model generated resource accumulations for *performing advances*, *deposits*, *non-performing advances* and *funding*. Note that the scales of each variable on the left-hand side of the graph differ per variable. The model generated resource accumulations correspond closely with that observed for the bank over the period of study. *Performing advances* shows a steady and continuous increase in value until 1998, whereafter the slope of the *performing advances* accumulation reduces significantly indicating the slowing growth in new advances due to the high interest rates experienced over this volatile period. *Retail deposits* show a similar, steady growth until 1998. Thereafter a significant reduction in the value of the resource accumulation takes place. This results in an increased need for *funding* as a result of the shortfall in *retail deposits* despite the lower growth in *performing advances*. Simultaneously, a clear increase in *non-performing advances* can be seen during 1999, showing a huge, but delayed increase following after the significant rise in interest rates.


Figure 4.3

Resource levels

1: performing advances...   2: retail deposits RETD   3: non performing adva...   4: funding FUND

1:	2.00e+011
2:	7.00e+010
3:	1.35e+009
4:	3.00e+010

1:	1.00e+011
2:	5.50e+010
3:	6.75e+008
4:	2.00e+010

1:	0.00
2:	4.00e+010
3:	0.00
4:	1.00e+010

1.00   12.80   24.60   36.40   48.20   60.00

Graph 1: p2 (Untitled)   Months   12:22 PM   Mon, Dec 31, 2001
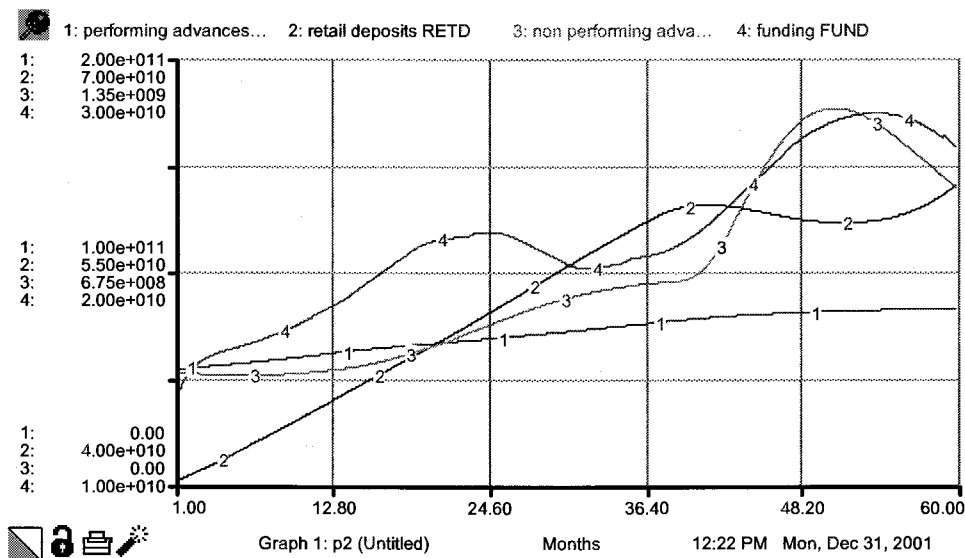
The impact on *interest paid*, *interest received* and *net interest received* (*interest received* minus *interest paid*) is shown in Figure 4.4. Clearly, the hike in interest rates results in the model generating a simultaneous increase in *interest paid* and *interest received*. The *net interest received* shows an important behavioural pattern; a sharp spike is indicated as interest rates rise and a sharp decline occurs as interest rates decline. This is a function of the resource structure of the interest income generation system of the bank. Due to the structure on the *performing advances*, *retail deposits* and *funding* resource accumulations, a specific performance pattern arises. In this instance, the *rate on advances* rises (declines) before the *rate on funding* rises (declines), that is, the structure of the funding book is such that the *rate on funding* lags behind the *rate on advances*. The consequence is that when interest rates

rise, the gap between *interest received* and *interest paid* widens resulting in an increase in *net interest received*. Similarly, when interest rates decline, the gap between *interest received* and *interest paid* narrows resulting in a decline in *net interest received*. Thus, the structure of the resource accumulations are responsible for the type of performance behaviour observed for this bank.

Figure 4.4

Net interest received monthly
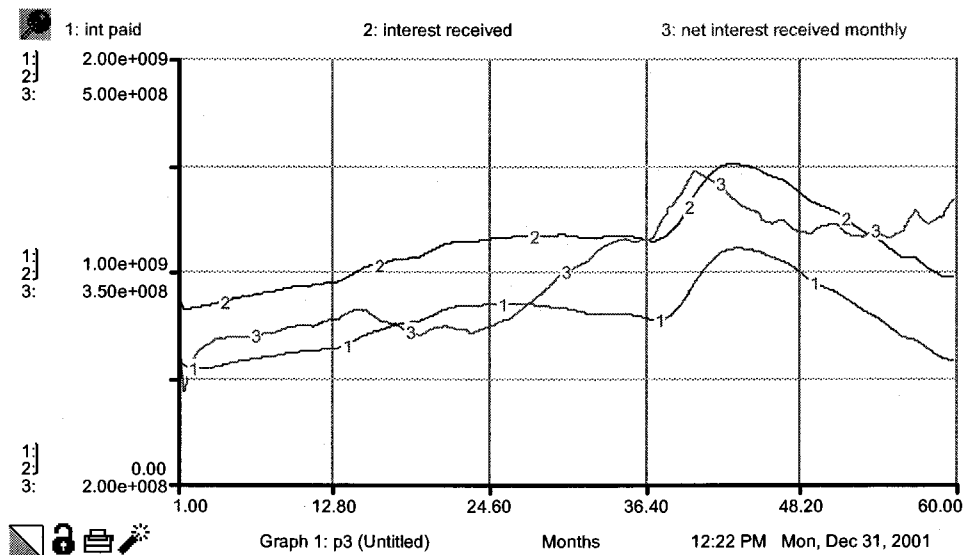
This phenomena is well understood from an asset and liability management perspective. Interest rates are one of the major sources of risk for banks. The term structure of their assets and liabilities determines the interest rate exposure that the bank faces. In an ideal world, a bank may wish to minimise this interest rate risk by seeking to finance all long-term assets with long –term liabilities and finance all short-term assets with short-term liabilities thus matching the term of each asset with a liability of equal term. When the term expires, both the rate on assets and the rate on liabilities can re-price simultaneously thus maintaining the interest differential between the assets and liabilities. Hedging in this fashion ensures that no adverse profitability problems are experienced by the bank during unforeseen interest rate volatility. This minimises the "downside" that the bank can experience when interest rates rise (fall) but also minimises the gains to be made when interest rates fall (rise). This theory of asset and liability management confirms the model behaviour against the theory. The model however, places this phenomena into a systems dynamics perspective. This aspect is discussed in detail in Chapter 5.

Given the net interest received as generated by the model, the bad debt provisioning generated by the model can be included and incorporating the non-interest income and operating (other) expenses the model generates the net income after taxation for comparison with that observed for the bank. Figure 4.5 illustrates the growth in bad debt provisioning for the simulation period showing the significant increase in bad debt after the interest rate rise.

Figure 4.5

Bad debt

Graph 1: p10 (Untitled)   Months   12:33 PM   Mon, Dec 31, 2001
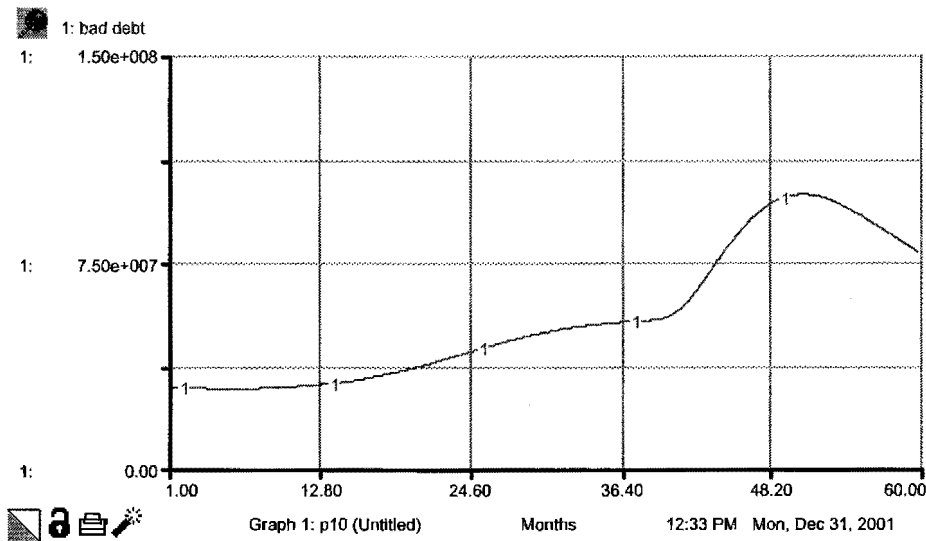
Given the model generated *net interest income* and *bad and doubtful advances* as well the exogenous inputs for *non-interest income* and *other expenses*, *net income before tax* and *net income after tax* is generated by the model.

Figure 4.6 illustrates the values used for non-interest income and other income. The values used are the values as reported by the bank for each financial year. This value was equally spread across the 12 months of the year to provide a monthly average value for *other expenses* and *non-interest income* and a profile of the behaviour over time.

Figure 4.7 illustrates the model generated net income after tax for the five year simulation period.

Figure 4.6

Non-interest income & other expenses


Graph 1: p4 (Untitled)   Months   12:27 PM   Mon, Dec 31, 2001
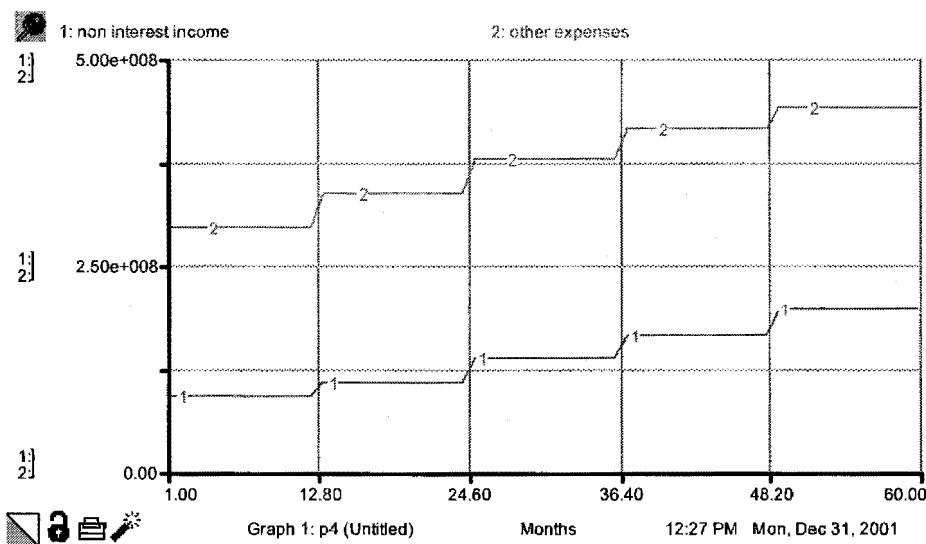
The graph of Figure 4.6 shows an annualised accumulating value for the net income after tax. The peak values show the end of financial year accumulations for the net income after tax. These values correspond to the values as reported by the bank in its financial year end results.

─── **Figure 4.7**

Net Income After Taxation

Graph 1: p5 (Untitled)   Months   12:27 PM Mon, Dec 31, 2001
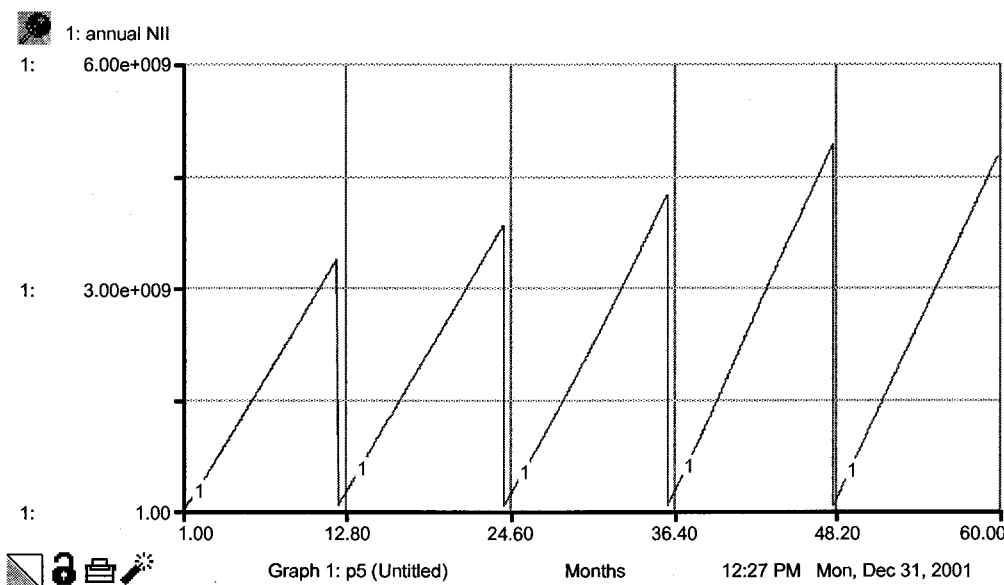
Clearly, a steady growth was experienced by the bank up to April 1999. The financial year 1999 to 2000 shows a significant reduction in the growth in *net income after tax* characterised by almost zero relative growth over the previous year. The bank experienced severe criticism from share analysts and other investors for it's poor performance during that year whilst other large banks weathered the storm far better.

The comparative year end values for the key variables for actual performance and the simulated values are given in table 4.1. The values for the key resources of *total advances*, *retail deposits* and *funding* closely track one another.

Net interest income shows a correlation in trend. The differences can be ascribed to the differences in the interest rate trends (Figure 4.2).

Bad & doubtful advances show a fairly large diversion during the reported period of 1998/1999. The simulated trend, however, follows the actual trend.

The simulated net income before tax and net income after tax are the consequence of the above trends.

Figure 4.7

Comparative values: Annual simulated versus reported values

		95/96	96/97	97/98	98/99	99/2000
Total advances	Reported	60,910.10	68,550.90	76,378.70	81,733.00	82,295.60
	Simulated	60,707.00	68,273.00	76,897.00	83,036.00	82,815.00
Retail Deposits	Reported	45,725.00	51,329.00	58,010.00	58,592.00	61,404.00
	Simulated	45,436.00	51,697.00	58,182.00	58,609.00	61,551.00
Funding	Reported	19,398.00	24,121.00	23,871.00	27,694.00	25,683.00
	Simulated	18,126.00	21,986.00	22,218.00	27,832.00	25,113.00
Net Interest Income	Reported	3,587.00	4,039.00	4,607.00	5,035.00	4,844.00
	Simulated	3,392.59	3,858.14	4,249.40	5,049.08	4,654.96
Bad & doubtful advances	Reported	283.00	353.30	542.20	1,104.20	1,138.60
	Simulated	295.86	350.10	542.46	804.65	1,294.47
Net Income Before Tax	Reported	847.10	953.50	1,201.20	942.30	882.20
	Simulated	922.52	648.34	929.29	1,360.89	630.67
Net Income After Tax	Reported	484.00	573.00	753.00	592.00	604.00
	Simulated	525.83	516.43	604.04	884.58	441.37
Cost-to-income ratio	Reported	75.10	74.90	71.70	70.50	72.20
	Simulated	73.00	77.00	76.00	70.00	74.00
Net Interest Margin	Reported	5.60	5.40	5.50	5.50	5.20
	Simulated	6.29	5.58	5.96	5.63	5.90
Depreciation	Reported	71.10	73.40	88.80	106.00	121.50
	Simulated	56.11	71.45	80.26	87.46	93.36
Allocated capital	Reported	2,434.20	2,440.90	3,090.90	3,514.80	3,745.00
	Simulated	2,540.98	2,902.48	3,325.31	3,944.51	4,253.47
Loan capital	Reported	536.60	882.30	917.20	1,404.40	1,275.00
	Simulated	547.13	714.17	927.42	1,169.04	1,258.44

Overall, the model does produce a rough but approximate and directionally correct set of trends. Since the purpose of this modelling approach is not accurate forecasting (other techniques may be more appropriate) but is to understand how the systemic resource structure influences the dynamics of performance and how we can adapt the structure to alter the trend for an improved performance. Therefore, our objective is to understand the causes of trend dynamics and how to alter the trend. We do not require precise forecasts to understand this.

4.3. Tests for consistency of the model structure.

4.3.1. Introduction

In a further set of tests, the model was exposed to senior executives and knowledgeable banking specialists who participated in model development work sessions. The purpose was not only to determine whether the trends produced by the simulations were deemed to be appropriate, but also to determine whether the trends were generated for the right reason. As a result, several modification were made to the structure of the model.

The structure of the model was built over 5 work sessions using a group model building approach [Vennix: 1996]. The core team consisted of representatives from Group Finance, Group Strategy, the head of an asset management division, the head of the retail banking division, as well as several members from several other units. Interviews were conducted with other knowledgeable persons from units such as risk management and asset and liability management as an when required.

The process focused around mapping the resources (stocks and flows) and relationships between resources during the work sessions. Between work sessions, the simulation model was developed, data research conducted and the simulations prepared for the next sessions. At the following sessions, the behaviour of the model was demonstrated and further debate and dialogue conducted to expand the model. After the five weekly sessions were concluded, the basic structure of the model had been developed and thereafter, further development and refinement of the model took place without the aid of the workshop team.

4.3.2. Face Validity

The structure of the model is conceptualised in a manner that represents the actual system in a logical way. Thus resource stocks represent actual recognizable resource accumulations. The only stocks that are not material resource flows are the stocks governing interest rate movements. However, these variable behave as stocks and are thus conceptualised as stocks. Perceptions are also conceptualised as stocks since the updating of beliefs also behave as accumulations. We believe the model map and stock and flow representation provides a measure of face validity [Richardson & Pugh: 1981].

4.3.3. Parameters and values

The parameters used have been developed based on our knowledge of the actual system within the bounds of our knowledge and perception of the system relationships. Thus, we have used, as far as is possible, parameters and parameter values that are consistent with the actual values of the system and that is recognisable by most individuals in the South African banking industry. Similarly, financial equations and ratios follow the accepted norms and traditions in calculating those values.

4.4.   Tests for the Suitability of Model Behaviour

4.4.1.   Surprise Behaviour

Whilst it has not been possible to test all possible scenarios, no surprise behaviour in direction of trends have been observed. The scale of movements in trends are not always correct, but the direction of the observed are explainable and appear to us to be correct. The relationships thus appear to be correct in direction, but further work needs to be done on refining the values attached to the relationships.

4.5.   Summary

The above tests provide points of contact with reality that allows us to refute or support the dynamic hypothesis. The results provided some confidence that the model would produce approximate but directionally correct trends. Further examination of the model in chapter 5 provides additional points of contact with reality that supports the hypothesis. This will be indicated at the relevant sections in chapter 5.

Chapter 5

Dynamic Complexity and Performance of the Resource System: Insights from the Retail Banking Model.

5.1. Introduction

Chapter 4 described the dynamic characteristics generated by the hypothesised model to demonstrate that the behaviour of the model is a reasonable representation of the actual interest income generation system of the bank under the conditions experienced by the bank over the time period 1 April 1995 to 1 April 2000.

In this chapter, we alter some of the assumptions that were developed in Chapter 4 to explore the sensitivity of the system to the policies of the decision agents and explore the dynamic characteristics of the system in response to alternative exogenous inputs. The insights obtained will be used to suggest improvements to the structure and policies of the system in an effort to improve the performance of the resource system.

In Chapter 4 the model was initialised to match the historic situation as at 1 April 1995. Such an approach allows us to investigate the replicability of the actual behaviour by the model. However, such an approach is not ideal in understanding the dynamic characteristics of the system because multiple complex patterns are used as exogenous inputs. The variety of simultaneous complex inputs provides a rich source of confounding variables making it difficult to understand the dynamic characteristics of the system structure. To overcome these difficulties, the key resources of the system are formulated for an equilibrium situation and are then disturbed to produce a resulting dynamic behaviour. Pure input conditions of known composition are used to generate a system response. The behaviour of this idealised system is described from the perspective of the dynamic resource systems view.

In the following sections we will investigate individual aspects of the idealised system structure in response to various system disturbances and the impact it has on the financial performance of the resource system. This insight allows us to develop hypotheses about appropriate choices, policies and structural changes that may be successful in improving the performance of the resource system. The following, limited number of aspects of the system, will be investigated under idealised conditions:
- Impact of asset and liability term structure;
- Impact of credit policies;
- Impact of capital holdings and the capital adequacy requirement;

- The cost-to-income ratio of a bank;
- Impact of dividend payouts to shareholders.

Having obtained some insights into the behaviour of the resource system in response to the change in single unique aspects, one at a time, we then test scenarios of multiple inputs, operating policies and capabilities to infer how our choices lead to the time path evolution of our key resources that give rise to performance. This is operationalised by investigating comparative scenarios of two banks with identical resource structures but with different levels of resource endowments, operating policies and capabilities. The purpose is to explain how differences in performance may arise for two similar banks.

Whilst Chapter 4 focused on demonstrating the model's ability to replicate the behaviour of the actual system under conditions experienced by the system over the simulation time horizon and thereby improve the confidence in the model, this chapter investigates the performance of the model under various conditions. The resulting behaviour provides a further number of points of contact with reality to validate the dynamic hypothesis by comparing the model behaviour with known theory.

5.2. The Idealised State of the Interest Income Generation System

In initialising the system the *performing advances*, and *retail deposits* (the key resources) are set to equilibrium by balancing the inflow and outflow rates for these resources. This is achieved by providing a constant inflow (rather than the historic inflow patterns) that matches the outflows from the resources. The exogenous *funding rate* is held at a constant 13 percentage points providing a stable external basis for equilibrium to exist.

Figure 5.1 illustrates the *funding rate, rate on advances* and *rate on deposits* for the idealised state. Note that the value of the *markup* to determine the *rate of advances* has been set at a constant 4% above the *funding rate*.

Figure 5.1

Interest rates

Interest rates
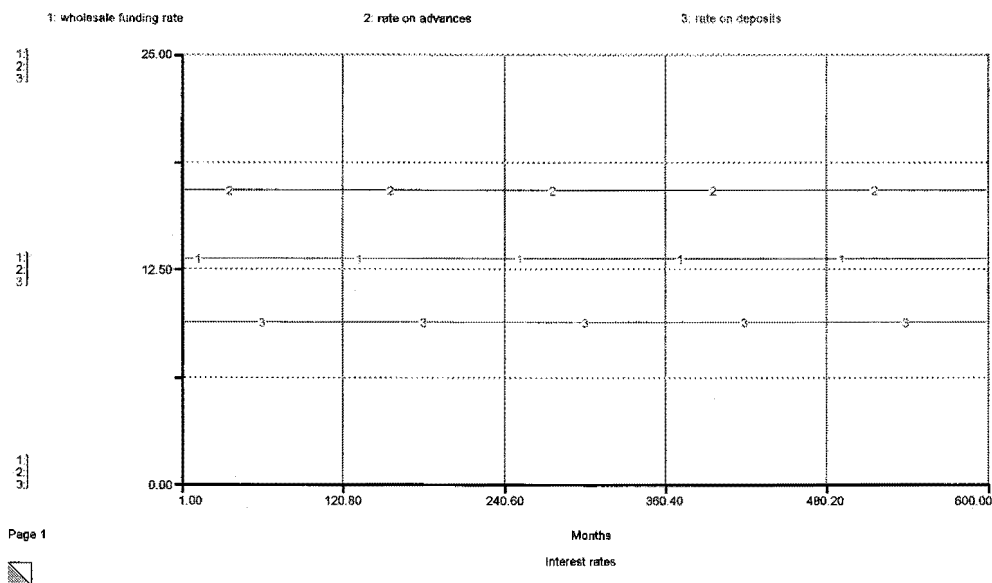
The key resources, *retail deposits* and *performing advances* have been set in equilibrium as illustrated in Figure 5.2. and are shown for a 600 month time period (50 years) to illustrate the long-term evolution of the key resources of the bank. *Operating costs, non-interest income, liquid asset fraction* and *book value of fixed assets* are similarly initialised at constant values or an equilibrium position. *Funding* (Figure 5.2) declines over time since retained earnings reduces the need for and resource of *funding* due to the accumulation of *Tier 1 capital*.

━━━ **Figure 5.2**

Key resources

1: performing advances   2: retail deposits RETD   3. non performing advances   4: funding   5: tier 1 capital

Page 2   Months

Key Resource Accumulations
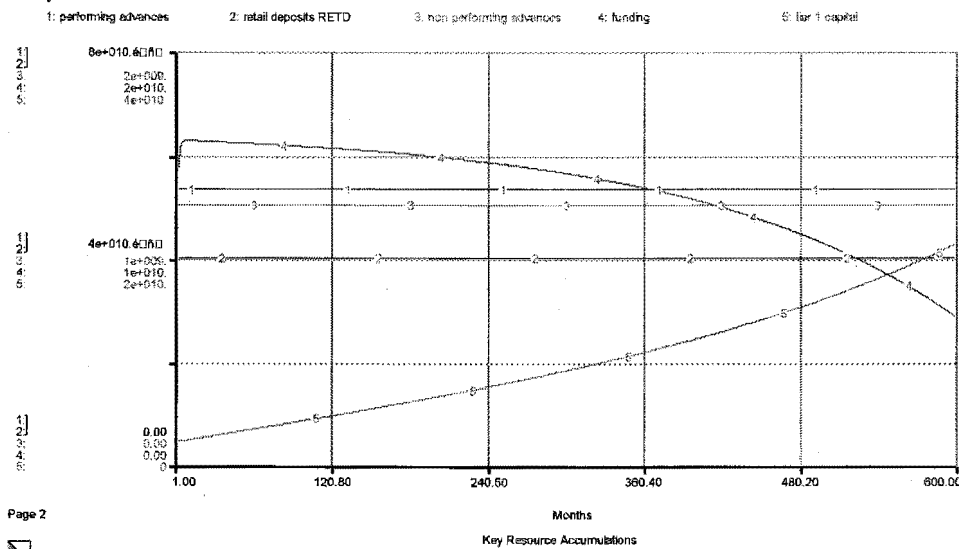
The initial increase in *funding* of figure 5.2 is an artifact of the model and not as a result of the dynamic characteristics of the system. However, this does not influence the behaviour of the system after the initial 6 month period has passed. To avoid confounding the impact of this dynamic with the dynamic of the system, all exogenous test inputs will be activated after the initial 12-month period has passed.

Figure 5.2 illustrates how the resource position improves over time with constant exogenous inputs and with performing advances and deposits in equilibrium. Under such conditions, the bank does not increase its business of making loans and taking deposits, this remains constant. Through *retained earnings*, *Tier 1 Capital* increases with time. This reduces the *funding* requirement of the bank. Note that the *funding* requirement declines more rapidly in later years. This behaviour illustrates that a high-order positive feedback loop is dominant. The key positive feedback loops are shown in Figure 5.3. As *Funding* declines, less interest is paid on *Funding* leading to an increase in *net income after tax* and thus a further increase in *tier 1 Capital*. Thus, under such equilibrium conditions, a bank can expect to improve its financial performance over time.

5.3

Figure 5.3

Key positive feedback loops
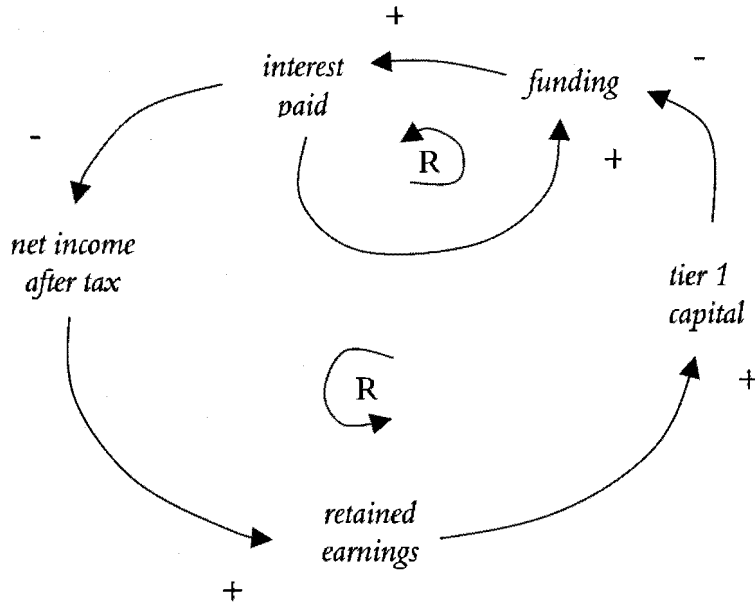
The resulting model generates an *annual net income after tax* that increases exponentially over the simulation time horizon (Figure 5.4). This model, under the described conditions, provides the idealised basis for testing the dynamic characteristics of the system.

Figure 5.4

Annualised net income after tax (NIAT)
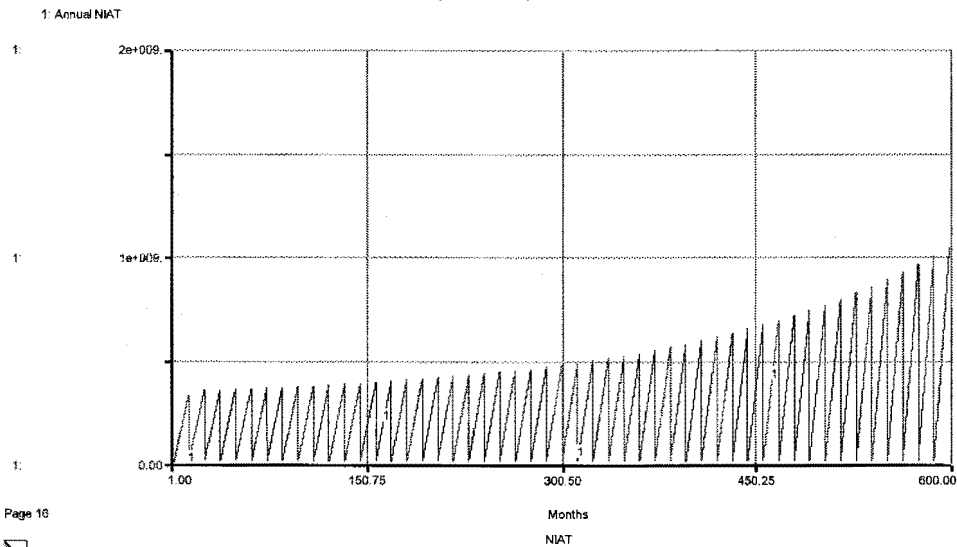
5.3.   The Systemic Impact of Asset and Liability Term Structure

5.3.1.   Asset and Liability structure: Impact of a longer funding term

To establish the dynamic behaviour of the *net interest income* generated with differing asset and liability term structures, we initially test the response of the idealised system with an asset book (*performing advances*) that re-prices before the *funding* and *retail deposit* book re-prices. A test input consisting of a step increase in *funding rate* by 7% from 13% to 20% is applied at month 24 and a step decline by 7% is applied after 6 months at month 30. Figure 5.5 illustrates the *net interest income* response for the system structure over a shorter, 5 year time horizon to provide a better resolution.

The long open position on funding ensures that assets re-price before liabilities re-price resulting in a significant gain in *net interest received* during the upswing of the interest rate cycle. However, during the downswing, the opposite occurs; a significant decline in *net interest income* can be observed. Thereafter, a steady state position is reached and held.

Figure 5.5

Net interest received monthly: long position on funding

Graph 1: p3 (Untitled)   Months   1:47 PM Wed, Jan 09, 2002
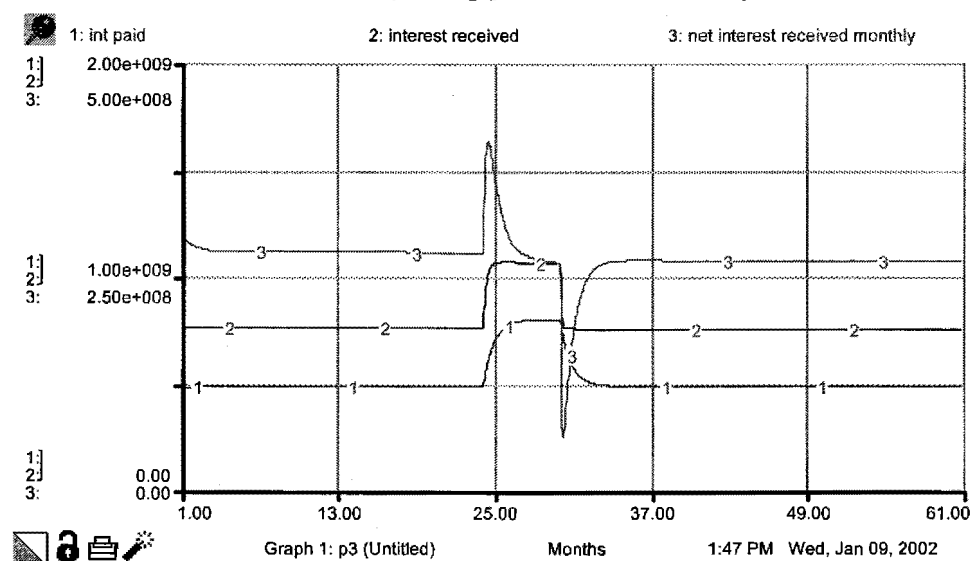
The amplitude of the *net interest received monthly* attained during the upswing of the interest rate cycle is exceeded by the amplitude of the downswing in *net interest received monthly*. The reason for this is due to the differing delays in acting by decision agents in re-pricing after the rates have moved in the funding market. There is great pressure on the decision agents, by clients, to delay any upward advance in interest rate whilst moving as rapidly as possible in reducing rates when able to do so. This representation of the psychological pressure under which decision agents must operate has been incorporated into the model by including the historical reaction times of the decision agents in re-pricing interest rates.

The pre-interest rate movement steady state position for *net interest received monthly* is maintained at a higher level than the post-interest rate movement level despite the fact that interest rates returned to their initial equilibrium position of 13%. The post-level of

net interest received monthly does not return to the initial level over the simulation horizon but maintains a lower value. The causal loop diagram of Figure 5.6 illustrates the systemic explanation for this situation.

The *net interest received monthly* during the upswing in the interest rate volatility is less than the *net interest received monthly* that was lost during the downward movement of the interest rates. The net result of net interest gained and lost is a loss of *net interest received monthly*. A lower *net interest received monthly* with a constant *performing advances* and *retail deposits* book results in a higher requirement for *funding* to compensate for the loss in cash from *net interest received monthly*. The higher *funding* requirement leads to a higher bill on *interest paid* which in turn leads to a further requirement on *funding* in a continuous, negative feedback loop until a new, higher, *funding* resource level is reached.

Figure 5.6

Key feedback loops

5.6
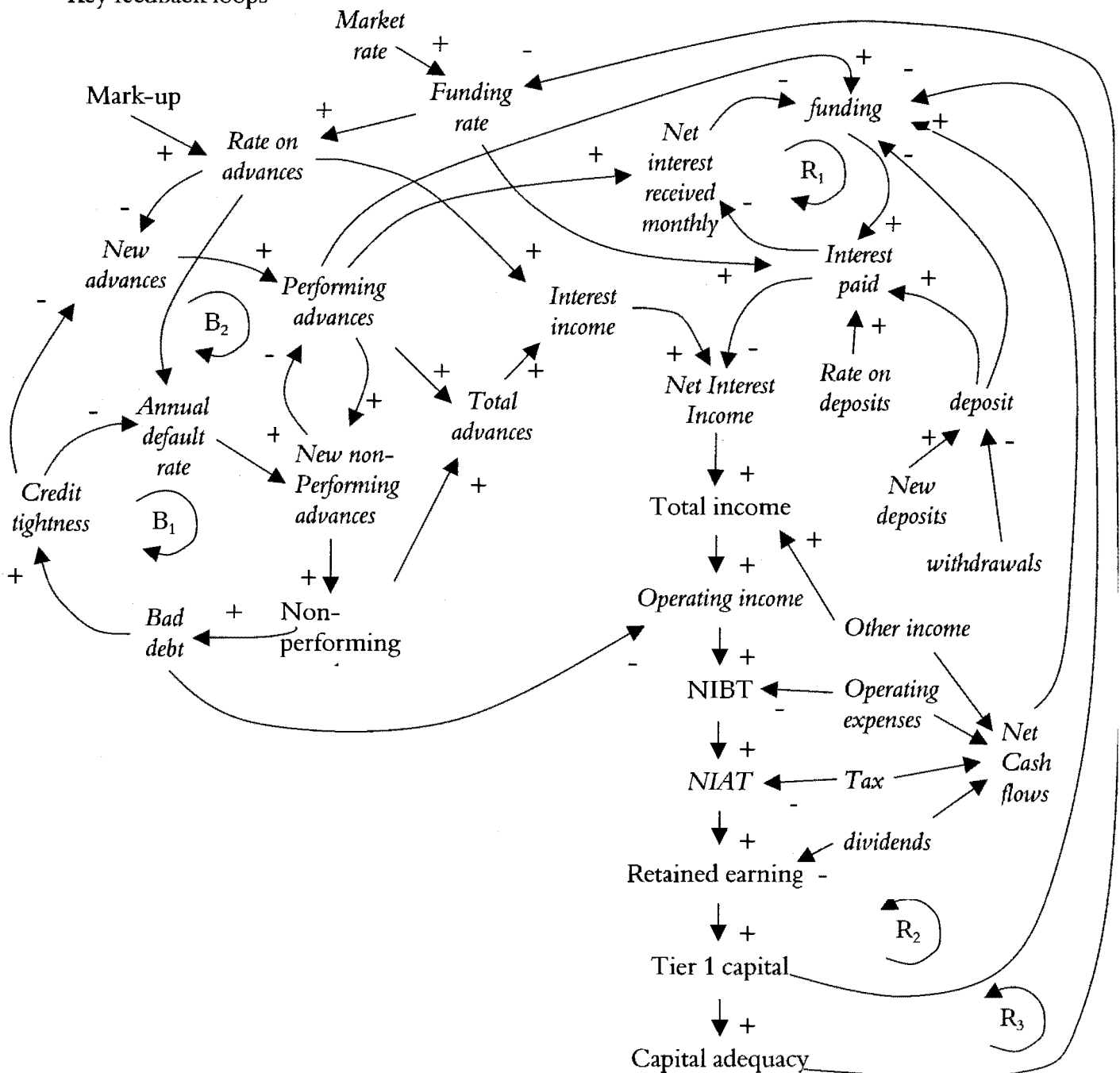
In addition, the higher *rate on advances* leads to a larger *annual default rate* and outflow of *performing advances* to *non-performing advances* reducing the *net interest received monthly* from *performing advances*. This increased funding requirement remains with the bank even after the interest rates have stabilised to their original position. Thus, with this term structure for its assets and liabilities, the bank can expect to be worse off under such interest rate movement conditions. This dynamic is usually masked by the growth in advances and is difficult to perceive with many confounding variables that act simultaneously to impact on the system's performance. A systemic view can provide some insight into this dynamic characteristic.

5.3.2. Asset and Liability structure: Impact of an equal term structure

Setting the delays between re-pricing of the *rate on advances*, *rate on deposits* and *funding rate* to an equal value of 1 month, that is, matching the terms of the assets and liabilities for the bank – a form of hedging against adverse interest rate movements under the same conditions as before results in an interest income pattern as illustrated in Figure 5.7.

Figure 5.7

Net interest received monthly: hedged book

Graph 1: p3 (Untitled) Months 8:04 AM Thu, Jan 10, 2002
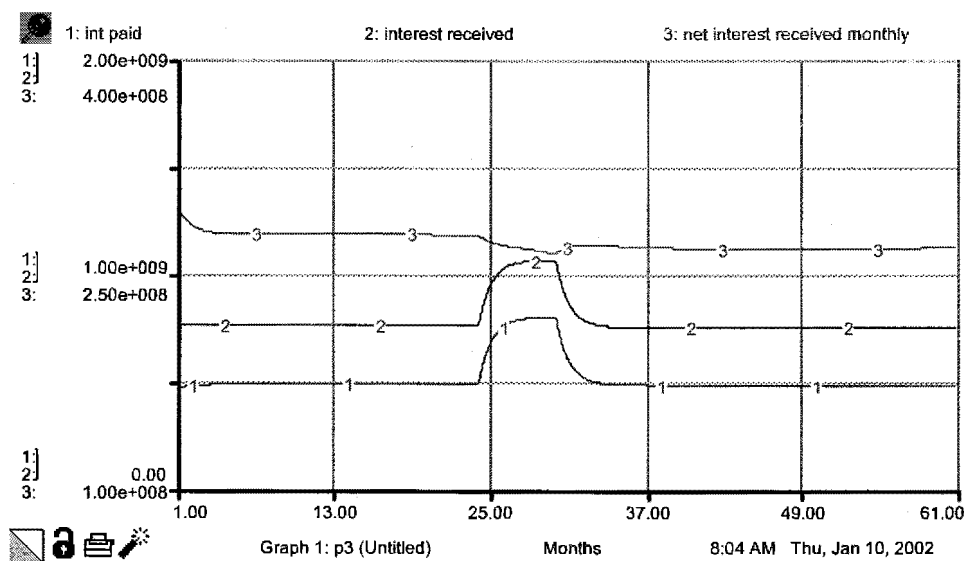
Comparison of Figure 5.5 with Figure 5.7 shows the difference in *net interest received monthly*. With the terms of the asset and liability books equal, Figure 5.7 exhibits a slightly declining *net interest received monthly* when interest rates rise. The sudden peak in *net interest received monthly* exhibited by Figure 5.5 is not present in Figure 5.7. Similarly, the rapid decline in *net interest received monthly*, which occurred when interest rates declined, is not present in Figure 5.7. The slight decline in *net interest received monthly* is due to the rising *annual default rate* that reduces *non-performing advances*, reducing the *net interest received monthly*. As shown in section 5.3.1, the *net interest received monthly* does not return to its initial level despite the interest rates achieving their original level. This is due to the additional *funding* burden required to maintain the system as explained in section 5.3.1. This section illustrates the impact of hedging in improving the financial

performance of the interest generating system without altering the resource system itself, i.e. via a decision policy of the decision agents.

5.3.3. Asset and Liability structure: Impact of a long asset term structure
An opposite term structure, that is, when the *funding* structure re-prices before the *performing advances* and *retail deposit* books re-price will have a different interest income pattern once again.

Figure 5.8 illustrates the *net interest received monthly* with a funding term structure that re-prices 3 weeks before *performing advances* and *retail deposits* re-price. Clearly, the direction of the peak value of *net interest received monthly* is opposite of that illustrated in Figure 5.5. With a short position on *funding*, Figure 5.8 shows that when interest rates rise, *net interest received* declines and when interest rates fall, *net interest received* increases. As with previous cases, the post-interest rate movement *net interest received monthly* settles at a level lower than the original equilibrium level.

Figure 5.8

Net interest received monthly: long asset term structure
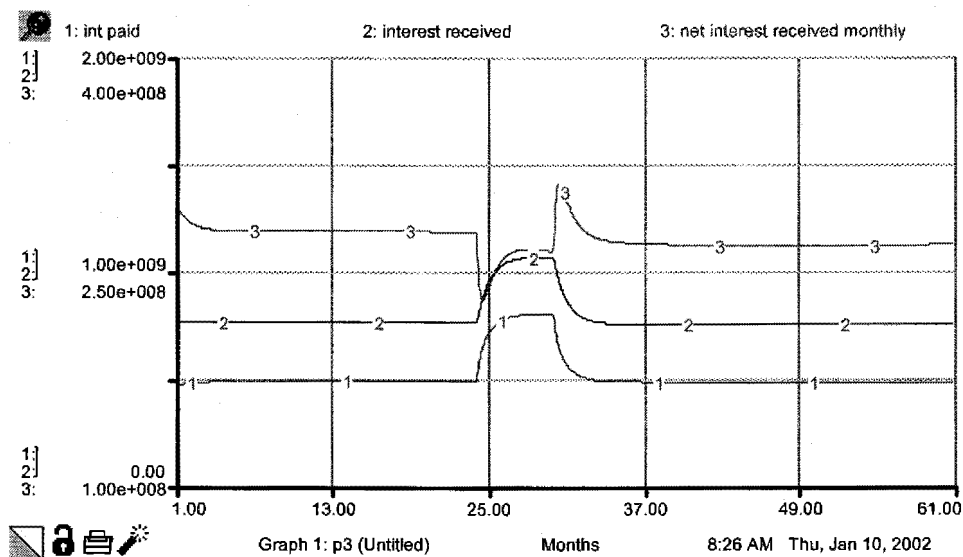
With the shorter time period for the rise in rates during 1998 and the longer time period experienced for the decline, this term structure would have been far more profitable than that illustrated in Figure 5.5. Understanding the impact of the asset and liability term structure and it's exposure to interest rate volatility is an essential part of bank risk management. "Institutions that operate without knowledge of the net duration of their assets are essentially going blind in the maelstrom of changing financial markets" [Jorion & Khoury: 1996]. This model behaviour is in accordance with the asset and liability management theory and provides a further checkpoint of reality for validating the dynamic hypothesis.

The model demonstrates that it is possible to obtain high level strategic insight on the impact of alternative asset and liability management policies on the performance of the system without large and data intensive models such as duration gap analysis models. Gathering the data is a primary hurdle to methods such as duration gap analysis [Jorion & Khoury: 1996]. The shortcoming of this approach is that performance results are approximations based on aggregate data and we cannot identify which loans or deposits are responsible for the performance and which loans or deposits to manage. Thus, whilst this approach may not be the most superior one from an asset and liability management point of view, from a strategic management perspective it holds promise to rapidly test the impact of various policies and structural changes on performance.

5.4. Impact of Credit Assessment Capabilities and Performance

Poor credit policies are a known source of risk for all major banks. Credit default remains a leading cause of bank failures [Mattem: 1996]. Clearly, a default on a loan results in lost income as well as the loss of the outstanding loan capital amount if it is not recovered. However, from a systemic perspective, there may be additional systemic costs not obvious and often obscured because of the difficulty in calculating the impact thereof.

Figure 5.6 shows the systemic interconnectedness of the system. A reduction in *performing advances* reduces the *net interest received monthly*. This results in a higher *funding* requirement to maintain the system resource balance. A higher *funding* requirement leads to an increase in *interest paid* that further reduces *net interest received monthly* resulting in a further increase in *funding* requirement, closing the negative feedback loop. In addition to maintain the performance the bank would have achieved without the *bad debt* requires that the bank take-on new interest bearing assets to replace the lost assets. The objective of this section is to investigate, from a systemic perspective, the impact of credit default and the implications in terms of replacing assets to maintain original financial performance.

The impact of credit default will be investigated by establishing the financial performance of the system under a scenario without any default rate and comparing this system performance with a default rate. The objective is to estimate the required additional increase in *performing advances* to match the financial performance that would have been attained under the no default rate scenario. This will allow us to estimate the required amount of *new performing advances* per Rand of *non-performing advances* to maintain the original financial performance.

$$ratio = \frac{performing\ advances_2 - performing\ advances_1}{non\ performing\ advances_2 - non\ performing\ advances_1}$$

For this experiment, the stock of *non-performing advances* is initialised at zero to remove any delays in the flow of *bad and doubtful advances* that may bias the results. Figure 5.9 shows the *net income after tax* that would be attained at a constant interest rate of 13% and without any default in *performing advances* taking place.

Figure 5.9

Accumulated net income after tax: zero default rate

Total accum NIAT: 1 -

```
1:        2e+012
1:        1e+012
1:            0
            1.00        120.80        240.60        360.40        480.20        600.00
```

Page 13   Months
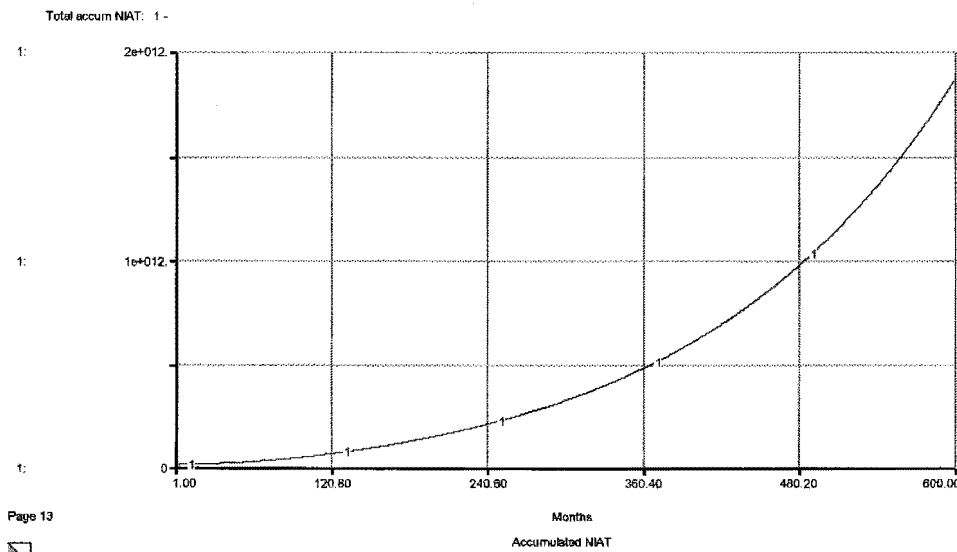
Accumulated NIAT

Figure 5.10 shows the reduction in *net income after tax* with a default rate included at a stable 13% rate on advances.

Figure 5.10

Accumulated net income after tax: default rate activated

Total accum NIAT: 1 - 2 -

```
1:        2e+012
1:        1e+012
1:            0
            1.00        120.80        240.60        360.40        480.20        600.00
```

Page 13   Months

Accumulated NIAT
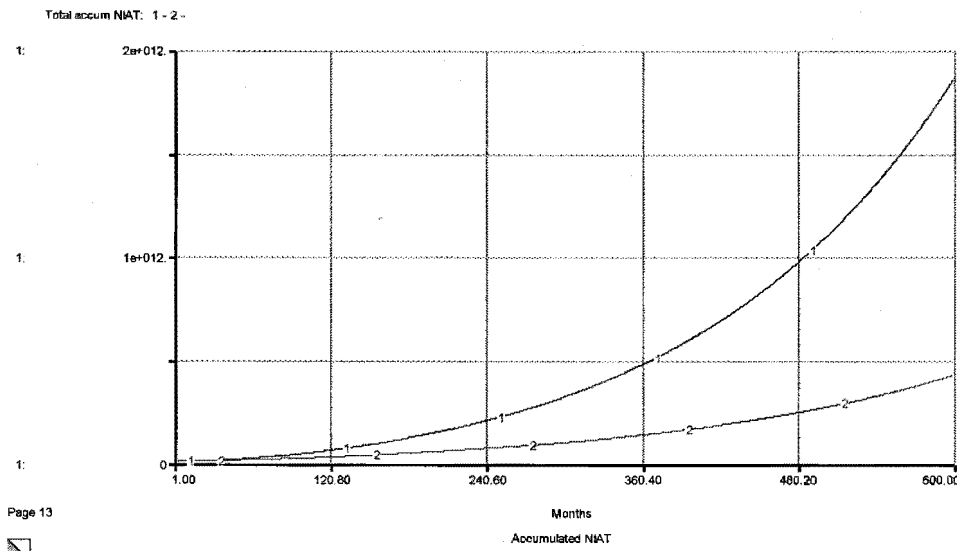
The reduction in *net income after tax* due to the increase in *non-performing advances* is significant. To regain the *net income after tax*, we increase the monthly rate of new advances until a growth rate in *new advances* is achieved that generates the original *net income after tax* trajectory. Note that this provides a conservative and hypothetical result; the *annual default rate* is kept constant at significantly higher rates of advances growth. In reality the default rate would be expected to increase as the rate of advances growth increases. Secondly, the additional administrative costs of taking on new advances are not

5.11

included in the simulation. The results are therefore conservative and underestimate the results that can be expected in the actual system.

The calculated ratio is:

$$ratio = \frac{(276.9 - 53.5)}{6.5}$$

$$= 34.4$$

Thus, conservatively estimated, at the *annual default rate* of 2,5% of *performing advances* (at 13% wholesale funding rate), 34,4 Rand is required for every one Rand of *non-performing advances*. It is assumed that all the *non-performing advances* are written off as *bad debt*.

The difference in performance between the two scenarios is not fully explained by the loss in advances (*bad debt*) and loss of *net interest income* due to the *non-performing advances*. The consequence of the above two factors results in an increase in *funding* requirement, raising *interest paid* that in turn requires additional *funding* (see Figure 5.6). This loop incurs additional costs in a recursive manner over and above the visible costs of the above two factors. Figure 5.11 shows the total accumulated *interest paid* for the two scenarios.

Figure 5.11

Total accumulated interest paid
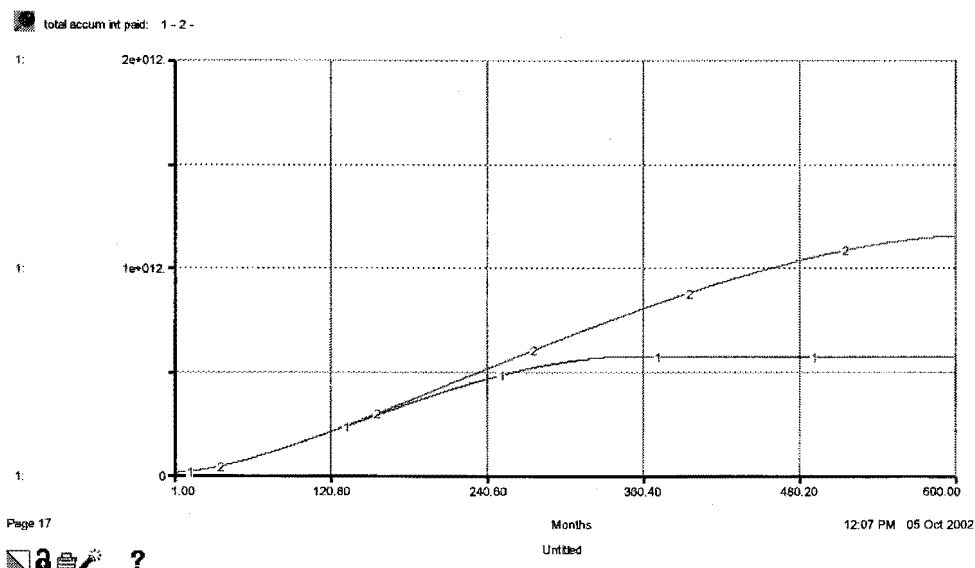
The non-linear increase in total accumulated *interest paid* of scenario 2, despite the linear increase in *non-performing advances*, is a result of the effect of the feedback funding loop. The growth in the *funding* loop is driven by the additional *funding* required to fund the *new advances*, as well as the new capital required to accommodate the growth in advances.

Thus the capital holdings impact on the funding requirement. The impact of capital holdings is discussed in more detail in the next section.

The effects discussed above are usually ignored due to the complexity in calculating the impacts. The system dynamics approach allows this complexity to be addressed and provides new insight into the dynamic behaviour of the system.

The implication for the system decision agents is:

- The required growth in advances to recover the financial position attainable without default is onerous and highly unlikely to be attained. Therefore it is may be more important to minimise credit risk than maximise advances growth.

We are now able to compare the long-term impact of asset and liability structure as discussed in section 5.3 with the impact of the credit assessment capabilities as discussed in this section. Figure 5.12 shows the long-term impact of an interest rate fluctuation as per section 5.3.

Figure 5.12

Accumulated net income after tax

Total accum NIAT: 1 - 2 - 3 - 4 -

Page 13

Months
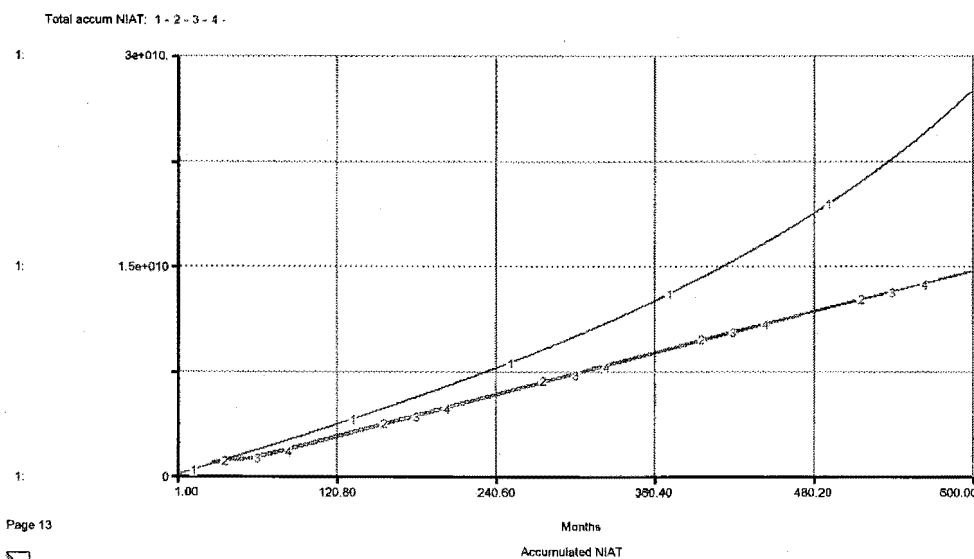
Accumulated NIAT

Curve 1 shows the growth in accumulated *net income after tax* under equilibrium conditions. Curves 2, 3 and 4 show the impact of the rise and decline in interest rates. Clearly, whatever asset and liability structure is chosen has a minimal influence on the accumulated net income after tax (comparison on curves 2, 3 and 4). The differences between curve 1 and the other curve is due to the *bad debt* flows that have occurred, reducing *net income after tax*, reducing the growth in *Tier 1 capital* and thus placing an additional need for *funding*. The higher *funding* requirement leads to higher *interest paid* on funding reducing *net income after tax* further. This impact is substantial in the long-run.

5.13

Figure 5.13 shows the increase in *non-performing advances* that drives the increase in *bad debt*. This increase is of limited duration and *non performing advances* settle back into an equilibrium value after the effects of the interest rate shocks have subsided. Yet, the impact on *funding* remains with the bank over the life of the bank.

Figure 5.13

Interest rate fluctuation impact on key resource accumulations
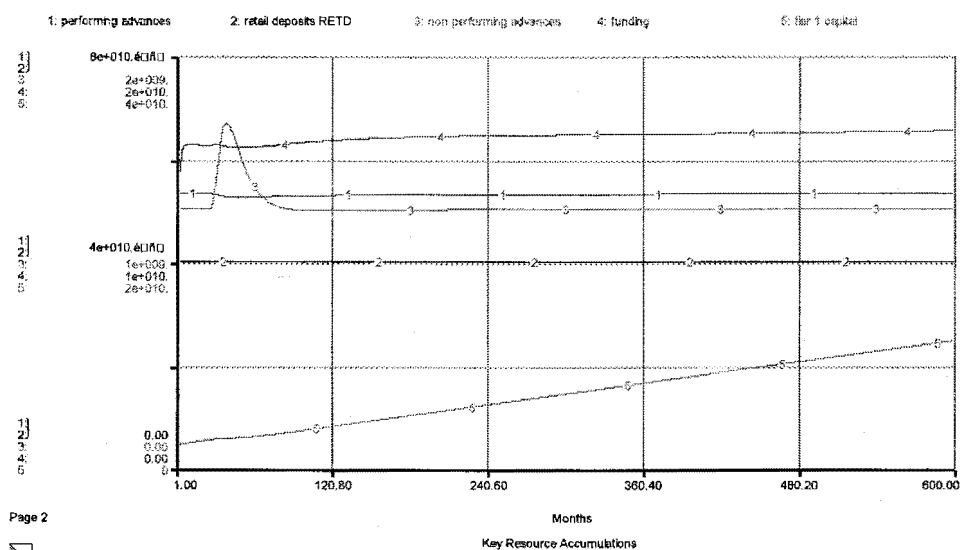
Comparison of Figure 5.13 with Figure 5.2 shows the impact of the interest rate fluctuations on the idealised bank. It is important to remember that this idealised bank is marginally profitable under equilibrium conditions, and any large shock to the system will have a larger impact than a bank that is highly profitable under equilibrium conditions. The conclusion reached is that credit policies and bad debt flows are far more likely to be significant in the long-run than the asset and liability structure.

5.14

5.5. Systemic Impact of capital holdings & the capital adequacy requirement

We now focus on the capital holdings of the bank, that is, *tier 1 capital* and *tier 2 capital*. We continue from section 5.4 by investigating the impact of *bad debt* on the capital holdings of the idealised bank.

Trend line 1 of Figure 5.14 shows the trend of *tier 1 capital* that would have been attained without any credit default. Trend line 2 shows the trend of *tier 1 capital* under the same conditions but with a normal credit default. *Tier 1 capital* is reduced by the flow of *bad debt*. Line 1 and line 2 show the characteristics of a positive feedback loop in action; line 1 shows exponential growth characteristics typical of a reinforcing feedback loop; without the bad debt, more cash is in the system reducing the *funding* requirement, the improved profit performance ensures improved retained earnings and higher *tier 1 capital* growth that reduces the *funding* requirement further. The reduced *funding* requirement leads to lower *interest paid* leading to a further reduction in *funding* requirement that improves profitability and *retained earnings* and so the spiral feeds on itself. Similarly, with the bad debt scenario (Line 2), the same positive feedback loop is at work. Line 2 displays a trend characteristic of a weak reinforcing feedback loop. With a higher *annual default rate*, this loop will be less active resulting in a slower growth.

Figure 5.14

Tier 1 Capital: Growth without and with bad debt

Tier 1 Capital
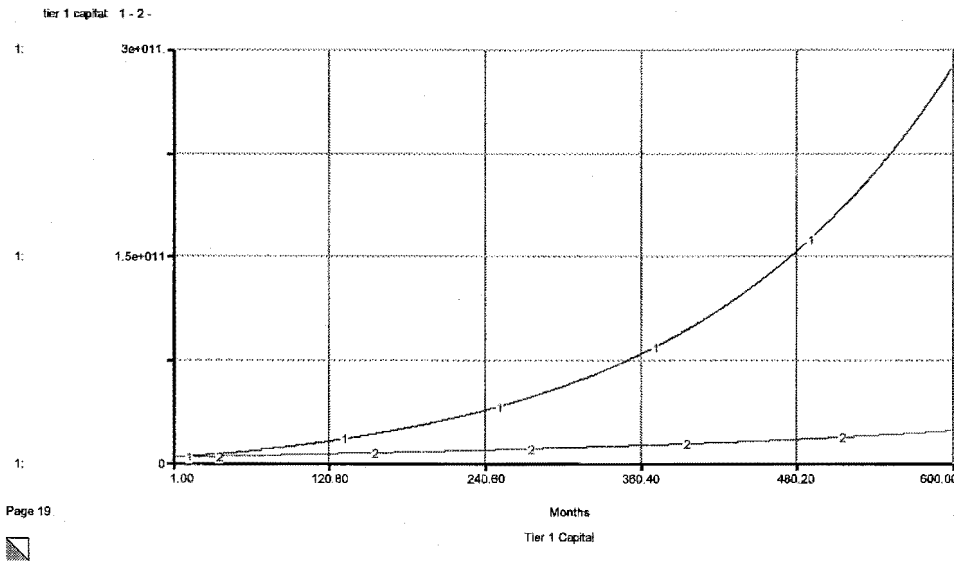
Figure 5.15 shows the impact of an *annual default rate* increase of 50% from 2,5% per annum to 3.75%. Under this scenario, trend line 3 shows a non-linear reduction with rapidly increasing destruction of capital whilst the increase in *bad debt* is linear. The reader is reminded that the scenario here is of a bank that is just making a normal profit under equilibrium conditions, that is, any small divergence of income or cost streams will produce have a significant impact on the performance and profitability of the entire

system. The horizontal scales of Figure 5.15 have been adjusted to show the impact of the capital destruction.

Figure 5.15

Tier 1 Capital: decline due to high levels of bad debt
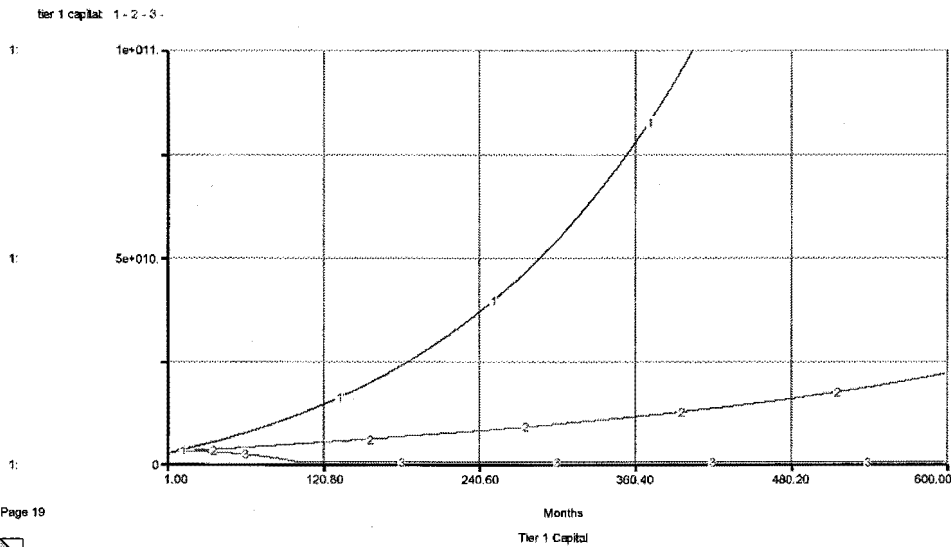
A reduction in *tier 1 capital* may lead to an additional *tier 2 capital* being acquired to ensure that there is sufficient capital to satisfy the capital adequacy requirement of the bank. However, *tier 2 capital* may not exceed *tier 1 capital*. Should the *tier 1 capital* and *tier 2 capital* be insufficient to satisfy the capital adequacy ratio, the bank should expect its credit rating in the market to deteriorate resulting in an increase in its *rate of funding*. The funding feedback loop would ensure a rapidly declining financial situation and rapidly declining *tier 1 capital* – a perilous situation for a bank.

5.16

5.6. The cost-to-income ratio of a bank

Reigning in costs remains a priority for South African Banks [KPMG Financial Services Group: 2000]. The most prominent measure of the efficiency of South African banks is the *cost-to-income ratio*. This measure is widely used by investment analysts and by the banks themselves.

$$cost-to-income\ ratio = \frac{total\ annual\ expenditure}{annual\ total\ income}$$

where:

$$annual\ total\ income = annual\ net\ interest\ income + annual\ total\ non-interest\ income$$

The main thrust of improving the *cost-to-income ratio* tends to focus on *operating expenditure* with issues such as information technology spend, staff costs and infrastructure costs dominating the agenda. Determining the impact of a cost reduction from a systemic perspective affords us the opportunity to investigate the impact of cost reduction initiatives on a bank with different levels of deposits (resources).

5.6.1. Impact of operating expenditure decline on Cost-to-income ratio

The first scenario is a comparison of the *cost-to-income ratio* of our idealised bank with a base level of *operating expenditure* and then with a 20% reduction in *operating expenditure*. This scenario is based on the idealised bank with all key resources and exogenous inputs in equilibrium so that we can detect the result of a change in *operating expenditure* only. Figure 5.16 illustrates the two alternative expenditure levels for the bank over a 50 year time horizon.

── **Figure 5.16**

Operating expenditure

5.17
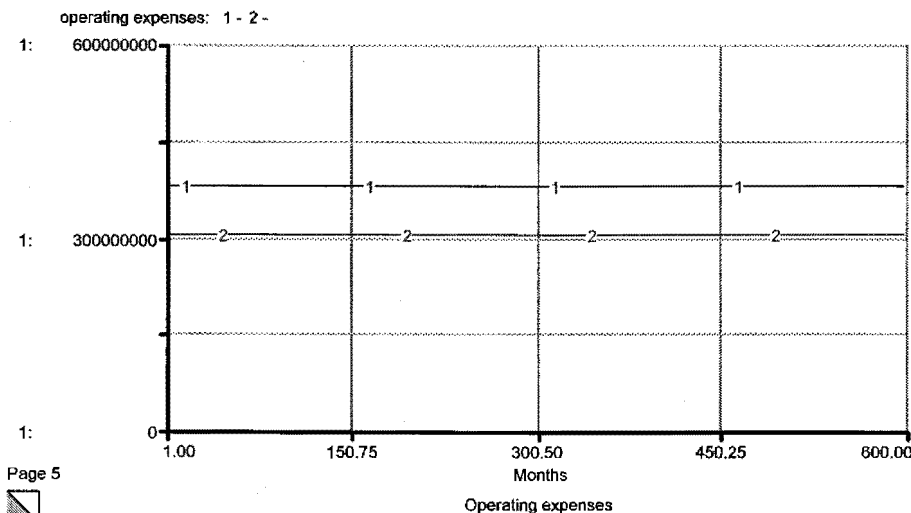
Figure 5.17 shows the result of *tier 1 capital* accumulation under the two scenarios. With a 20% reduction in *operating expenditure*, the *tier 1 capital* growths rapidly. This results in a reduction in the *funding* requirement that results in less *interest paid*, resulting in a lower *funding* requirement. Figure 5.17 illustrates the reduction in funding over the 50-year period leading to a negative funding requirement (cash surplus).

Figure 5.17

Tier 1 Capital Accumulation

tier 1 capital: 1 - 2 -

1:	2e+011.
1:	1e+011.
1:	0

1.00   120.80   240.60   360.40   480.20   600.00

Page 19

Months

Tier 1 Capital
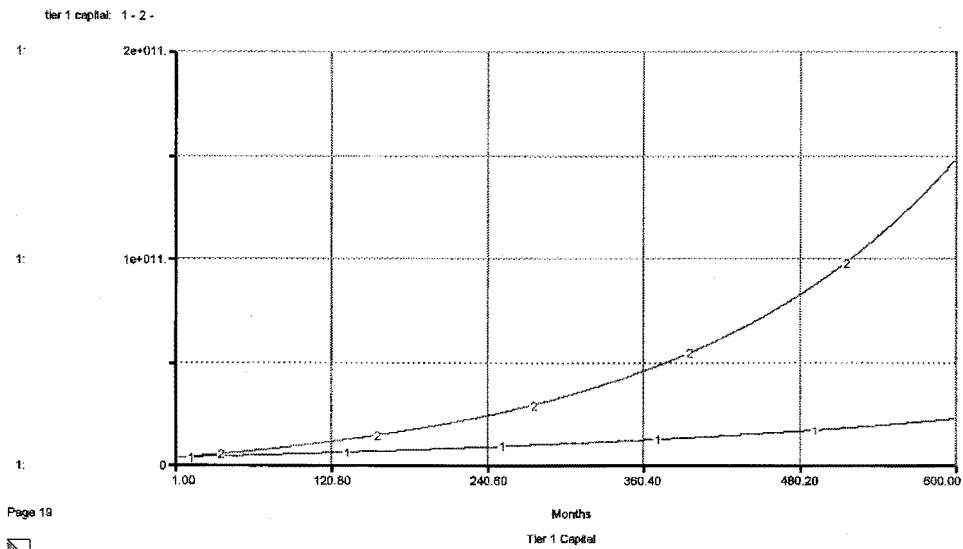
The reduction in funding shows signs of incremental non-liner behaviour.

Figure 5.18

Funding

funding: 1 - 2 -

1:	5e+010.
1:	-5e+010.
1:	-1.5e+011

1.00   120.80   240.60   360.40   480.20   600.00

Page 3

Months

Funding

5.18
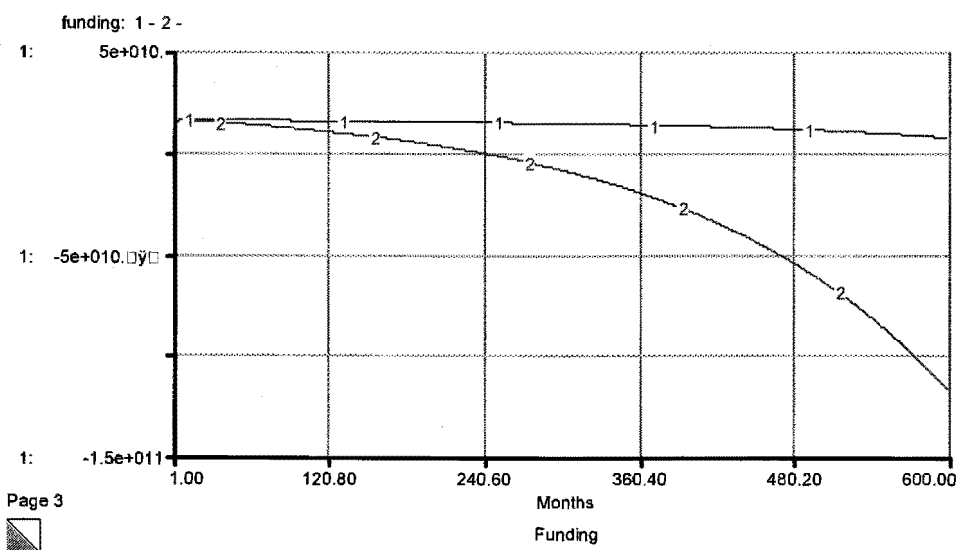
The result on the *cost-to-income* ratio is the ever increasing reduction in *cost-to-income*. However, the decline is not linear. The gains of a fixed 20% reduction is amplified through the feedback loop structures of the system, reinforcing the original change in *operating expenditure* into a non-linear and increasing gain in *cost-to-income ratio*.

―― **Figure 5.19**

Cost-to-income ratio

cost to income: 1 - 2 -

Page 6

Cost-to-income ratio
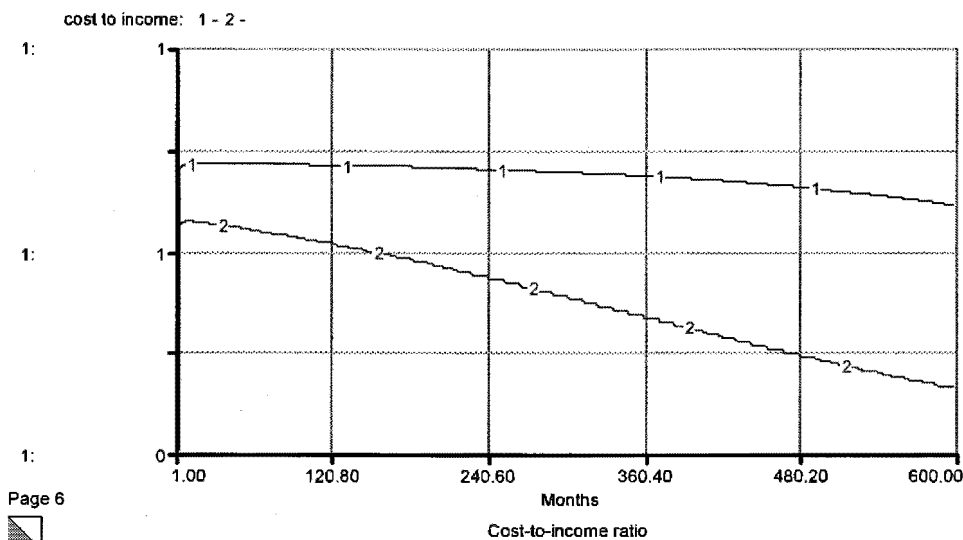
The performance advantage that arises has a strong time dimension that can easily be overlooked. Since the *tier 1 capital* and *funding* resource accumulations are key resources in driving the *cost-to-income* ratio down and since it takes time to build *the tier 1 capital* accumulation and to reduce the *funding* accumulation, the reduction of *cost-to-income* cannot be attained instantaneously. Whilst the reduction in *operating expenditure* may be instantaneous, the resources take time to build and decay. Because of this accumulation effect, a 20% reduction in operating expenditure, today, is not the same as a 20% reduction in operating expenditure tomorrow, all other things being even.

Line 1 of Figure 5.20 shows our baseline *cost-to-income ratio* of our idealised bank (scenario 1); line 2 shows the same bank with a 20% lower *operating expenditure* (scenario 2); line 3 shows the bank with a 20% lower *operating expenditure* after 18 months (scenario 3), matching the expenditure cut of scenario 2.

The vertical scale of Figure 5.20 lies between 0 and 1. At end of year 5, the difference in *cost-to-income* ratio for scenario 2 and scenario 3 is:

$$= 0.166 - 0.157$$

$$= 0.009$$

Thus the difference amounts to 0,9 of a percent.

The delay of 18 months results in a performance disadvantage of nearly 1% in *cost-to-income* ratio and the gains increase over time, albeit at a low rate, under these equilibrium scenarios.

Figure 5.20

Cost-to-income ratio

cost to income: 1 - 2 - 3 -

Page 6

Months

Cost-to-income ratio
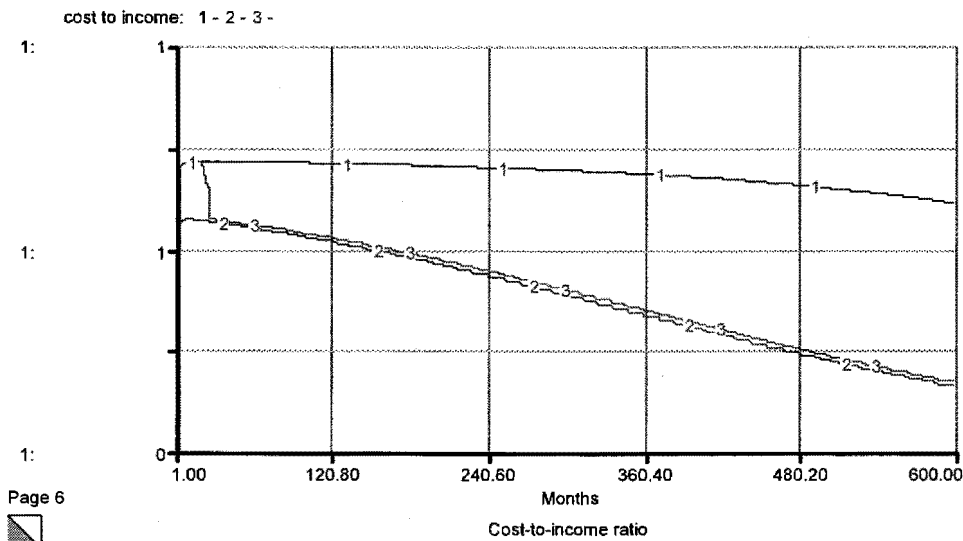
Because of the non-linear feedback structure, a bank that wishes to catch-up to a rival in cost-to-income ratio reduction by reducing its own operating expenditure by the same amount as a rival bank will still lag behind the initiator bank because of the feedback loop structures that reinforce the dynamic gains. Thus the performance is tied to a time dynamic. It is not sufficient for a bank to match the initiator bank, but it would have to exceed the 20% reduction in expenditure to catch up.

5.20

5.7. The Resource System and Dividend Payouts

Next we investigate the impact of the dividend policy of a bank on the future performance of the interest income generating resource system of a bank.

The payment of dividends to shareholders is a financial activity normally not associated with the future growth in interest income. This is because dividend payouts are far removed from the interest income generation system in terms of managerial control. However, once again, the dividend policy is systemically intertwined with the interest income generation system via the funding feedback loops. Figure 5.21, 5.22 and 5.23 shows the impact of alternative dividend policies on the accumulation of *tier 1 capital*, *funding* and the *net income after tax (NIAT)*. The *dividend policy* is varied from a payout level of 0% of *NIAT* to 100% of *NIAT* in increasing increments of 10%.

Figure 5.21

Reduction in Tier 1 Capital for increasing dividend payouts
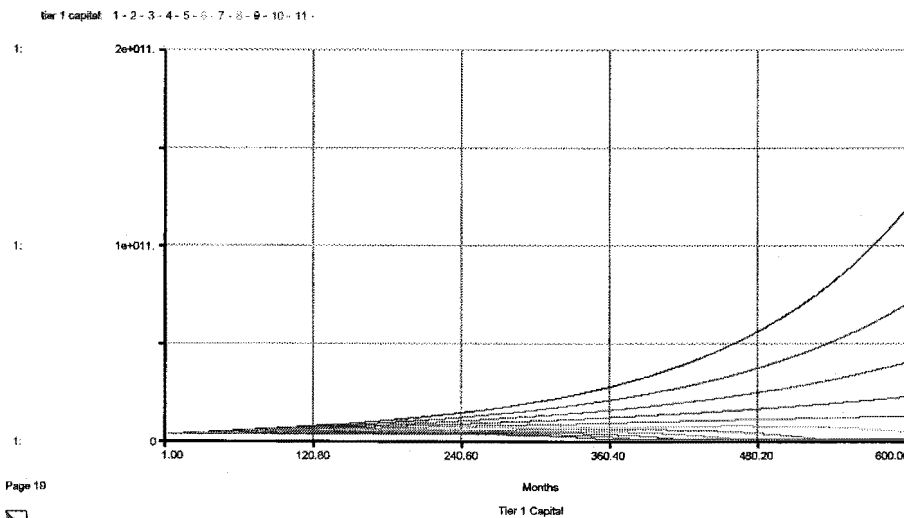
Figure 5.22

Increase in funding for increasing dividend payouts
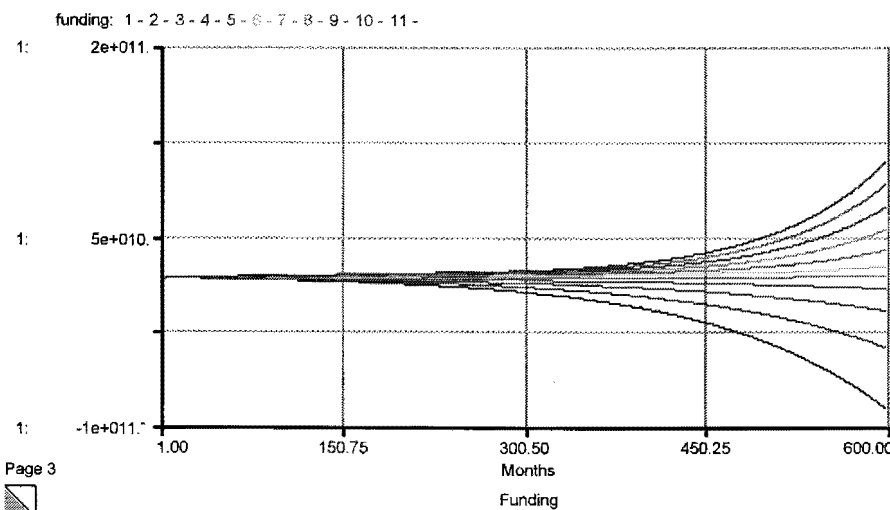
Figure 5.21 shows the reduction in accumulation of *tier 1 capital* as the dividend payout increases for the idealised system under equilibrium conditions. Figure 5.22 shows the increase in accumulation of *funding* under the same set of scenarios, whilst Figure 5.23 shows the reduction in monthly *net income after tax*.

━━ **Figure 5.23**

Reduction in net income after tax for increasing dividend payouts

Page 4

Months

Monthly NIAT
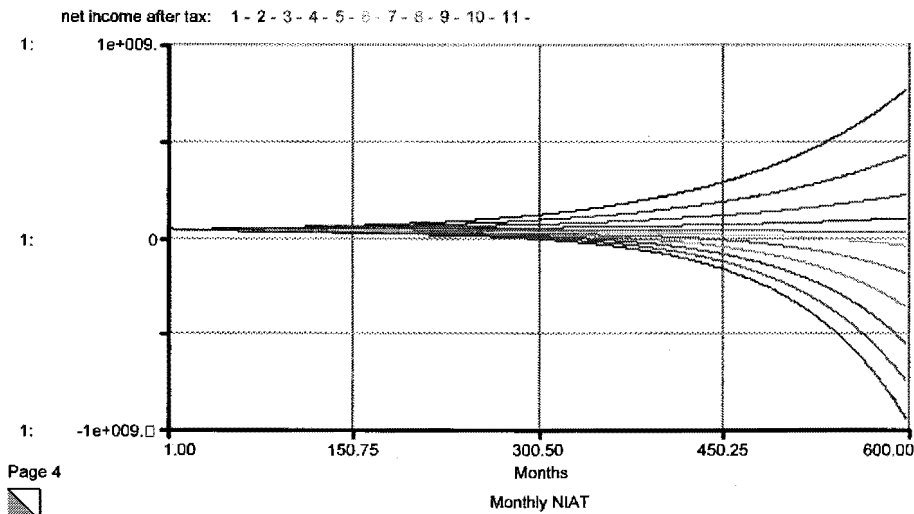
An increasing value for *retained earnings* flowing into the *tier 1 capital* accumulating stock leads to an exponential growth in *tier 1 capital*. This is because *tier 1 capital* is a resource accumulation embedded in a first-order positive feedback structure.

The equation describing the level of a resource within a first-order positive feedback structure is given by [Goodman: 1974]:

$$LEV(t) = LEV(0) \times e^{const \times t}.$$

Where;

$LEV(t)$ = level of the resource at time (t).

$LEV(0)$ = level of the resource at time (0).

Const = relationship between the level of the resource and the rate of flow into the resource $(1/T)$ where T is the time unit in use.

5.22

The doubling time is defined as the time interval required for the exponentially growing level to double in value [Goodman: 1974]:

$$2LEV(0) = LEV(0) \times e^{const \times Td}$$

$$2 = e^{const \times Td}$$

$$\ln 2 = const \times Td$$

$$0.693 = (\frac{1}{T})Td$$

$$Td = 0.693T$$

where:

Td = doubling time

Thus, for every time period of $0.693T$ the value of the level doubles. The time span over which growth occurs is important in determining the behaviour of the system. If the observation time is too short (such as a fraction of the doubling time), the growth of the resource variable may appear minimal. The accumulation of tier 1 capital follows this principle. Thus, even though it may be difficult to see the exponential growth in the early years, the underlying structure is at work manifesting the observed behaviour.

Figure 5.24 shows the net income after tax accumulated over the five-year time horizon. The accumulated values show the non-linear impact of the change in dividend payouts.

Figure 5.24

Reducing accumulated net income after tax

Total accum NIAT; 1 - 2 - 3 - 4 - 5 - 7 - 8 - 9 - 10 - 11 -

Months

Accumulated NIAT
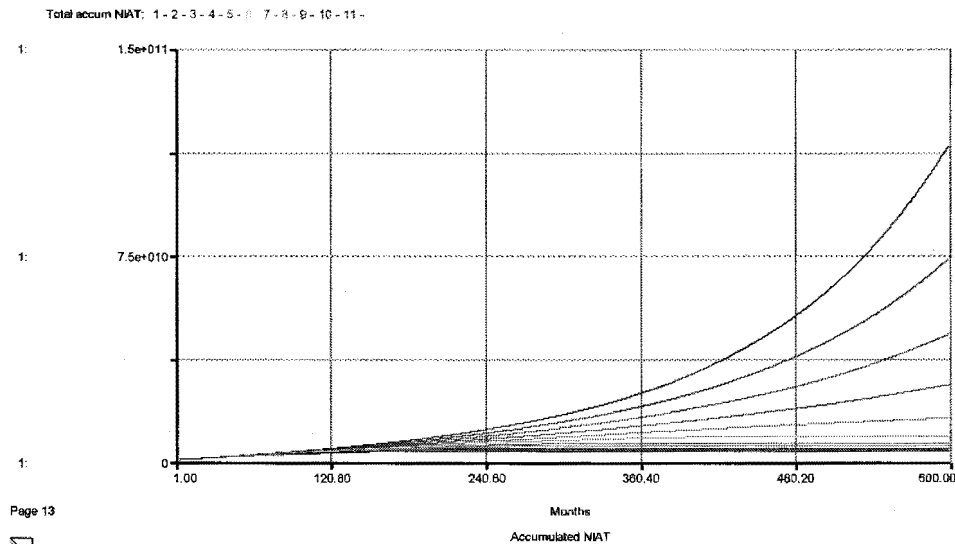
The impact of dividend payout is only realised in the following time period. There is a delay between the dividend payout and the results in the following financial period. Thus, the net income after tax for time period $t+1$ and the absolute value of the dividend payout is determined by the state of the resource system over the period $t+0$ to $t+1$ and the dividend payout in time period $t+0$. Figure 5.25 illustrates the feedback structure and delay.

Feedback structure affected by dividends

+

interest
paid ← ─── funding   −

− R   +

net income
after tax

tier 1
capital

R   +

dividend
payout   retained
earnings

+   +

dividend
policy   +   +
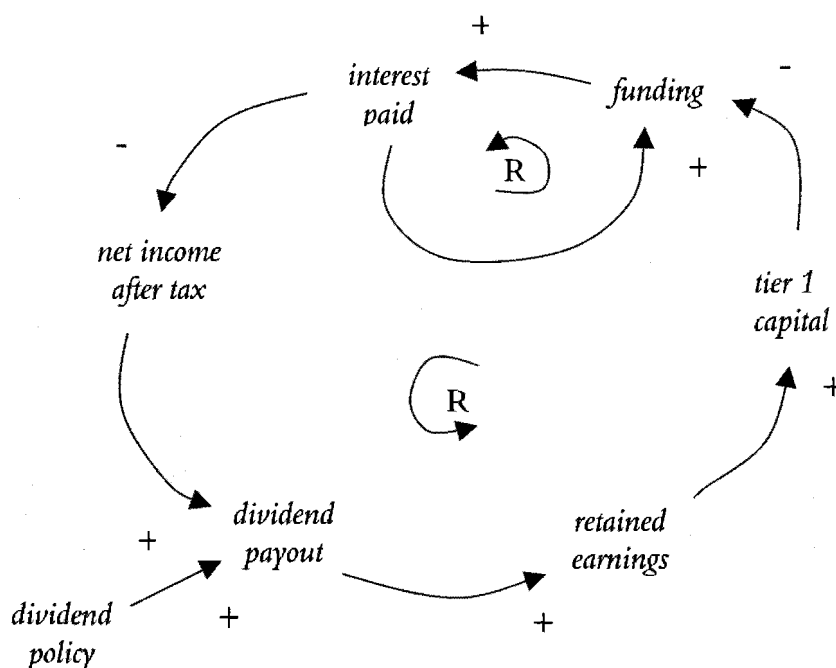
As *funding* increases, *interest paid* increases, which results in a larger *funding* requirement in the following time period that increases the *interest paid* in the following time period. It is this structure that is responsible for the non-linear gains as a result on a disturbance to the system. Clearly, the comparison of the impact of a change in dividend policy to a change in *operating expenditure* and a change in *non-performing advances* shows differing levels of impact on the system. Thus, we may be able to identify leverage points, points of high impact, that may detrimentally or positively affect the performance of the system.

From a resource system perspective, it is easy for managers to make short-term reallocations of cash to dividend payouts rather than to support funding reductions and tier 1 capital growth. The pressure to continue dividend growth may tempt managers to do so because they cannot alter the performance of the resource system in the very short term [Warren: 1999]. Altering performance requires substantial change to the resource levels. Whilst resource flows can be changed instantaneously, the accumulation of resources requires a continuous and persistent flow of resources over a sustained period of time, thus generally rendering managers helpless to alter performance in the short term. The pressure to improve investor payouts may result in the depletion of tier 1 capital and the unnecessary growth of funding leading to a poorer resource position over time damaging the interest income generating resource system.

5.8. Investigating Performance Differences for Banks with Identical Structures and Resource Endowments but different Policies and capabilities.

The previous sections have focused on the resulting behaviour of the interest income generating system as a result of a change to a single aspect of the system. The model is now viewed from the perspectives of two different banks with identical structures and levels of resource endowments, but with different operating policies and capabilities. The purpose is to take a resource-based view to explaining how differences in performance may arise between different banks. We undertake comparative experiments to infer how performance differences may arise.

Individual resource accumulations such as the *performing advances* have no particular value on their own. The accumulation or decay of resource stocks are often dependent on other stocks, for example, the *funding* resource is dependent on the accumulations in the *retail deposits* stock, *performing advances* stock and *capital* stocks. Thus, the difficulty in building the resource levels of a stock is not dependent only on the initial level of that stock but also on the initial levels of the other stocks that influence it [Dierickx & Cool: 1989]. Thus, the manager's challenge is to assemble of system of resources that work well together [Warren: 1999]. The implication is that managers must appreciate that they develop resources from those resources they already have. We will now examine the interdependencies of the resource structure and its performance as a result of policy and capability differences to provide some insight into the implications for managing the resource system.

We initiate the experiment for two identical banks with identical initial resource positions but with different policies and capabilities for guiding the resource flows under a dynamic interest rate environment. The simulator can be initialised with many different initial positions. For the purposes of this investigation the resource positions and capability differences are as follows:

Bank 1:
In terms of its funding position, bank 1 is initialised with a short-funded position that is typical of most large South African Banks. i.e. has a natural maturity mismatch between short-dated liabilities and longer-dated assets exposing the bank to interest rate risk. Whilst the quantity and quality of resources are the same for both banks, bank 1 has an advantage in two capabilities: a 20% stronger capability in credit assessment and a 5% better capability in attracting deposits. Capability is defined precisely; a 20% better credit assessment capability results in 20% lower annual default rate than the competitor and a 5% better deposit attracting capability results in 5% more deposits being placed at bank 1 than bank 2 per month. Thus, if the competitor has a 2,0% annual default rate, Bank 1 will be initialised with a default rate of 1,6%.

Bank 2:
Bank 2 is initialised with a long-funded position, i.e. has a maturity mismatch between long-dated liabilities and short dated assets exposing the bank to interest rate risk.

Both banks are subject to the same resource growth conditions and have identical structures. Both banks experience an equal 10% annual growth in advances and non-interest income as well as an annual 7% growth in expenses. Both banks are exposed to a

volatile interest rate environment. Figure 5.26 shows the base interest rate movement for both banks. The impact is investigated over a 5-year time horizon.

━━ **Figure 5.26**

Base interest rate movements
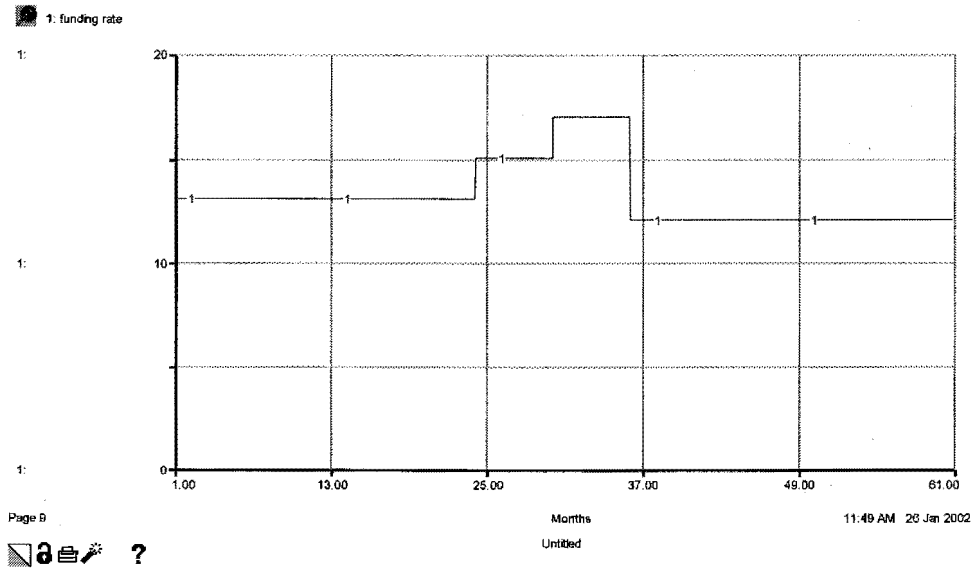
The results indicate substantial differences in performance over the 5-year period resulting in substantially different resource endowments at the end of the 5-year period. Figure 5.27 shows the trajectory for the key strategic resources of *performing advances, non-performing advances, retail deposits* and *funding* for Bank 1. Figure 5.28 shows the trajectory of the resource accumulations for Bank 2.

━━ **Figure 5.27**

Bank 1: Trajectory of key resource
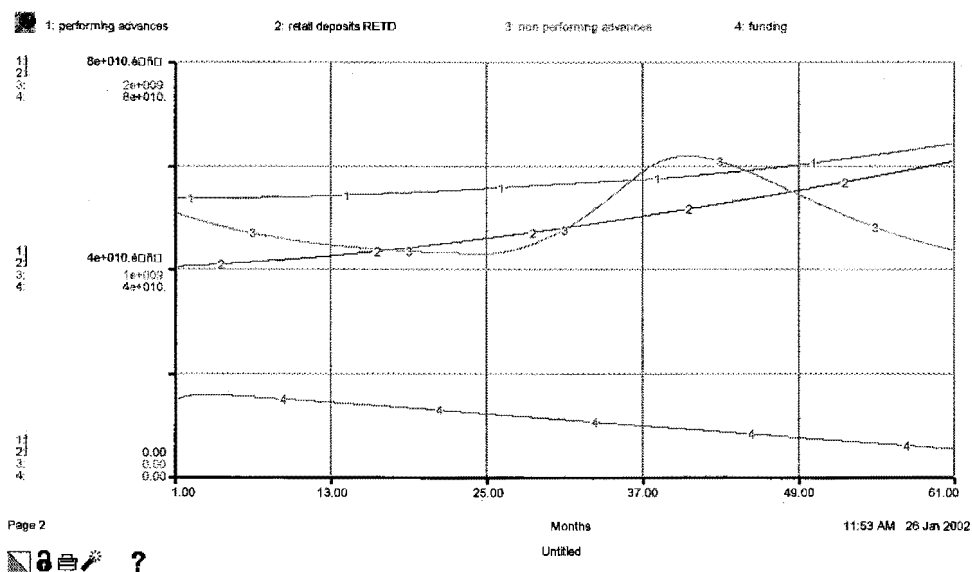
Bank 2: Trajectory of key resources
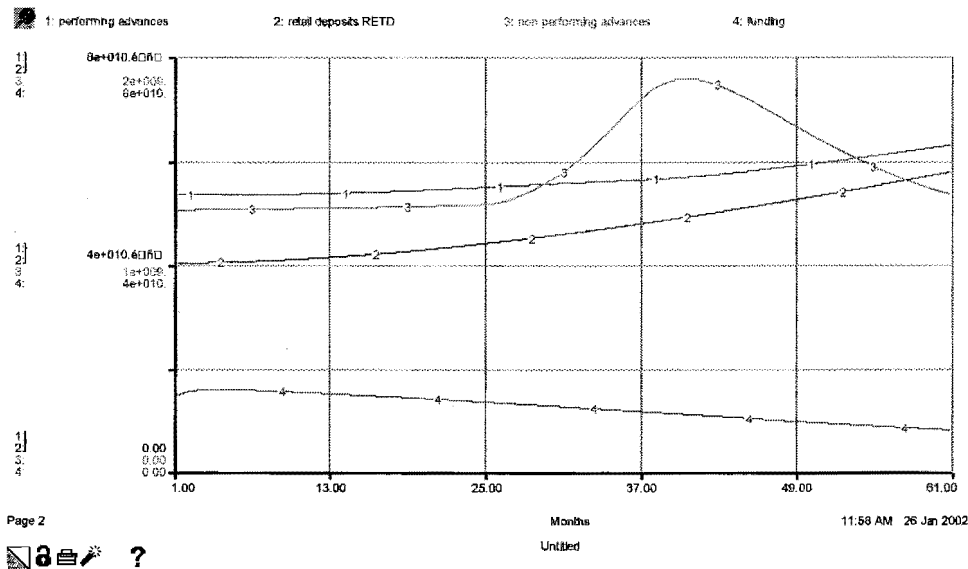
Bank 1 shows a higher ending resource position for retail deposits and performing advances and a lower position in funding than its rival, Bank 2. The capability difference in credit assessment results in a substantial difference in non-performing advances. Clearly, Bank 1 has been much better than Bank 2 in managing its resource position and ends in a stronger resource position. This is reflected in the final resource positions of the two banks.

The result of this resource difference is shown in Figure 5.29 and 5.30. Figure 5.29 shows the *interest income, interest paid* and *net interest received monthly* for Bank 1. Figure 5.30 reflects the same variables for Bank 2.

Bank 1: interest received and interest paid
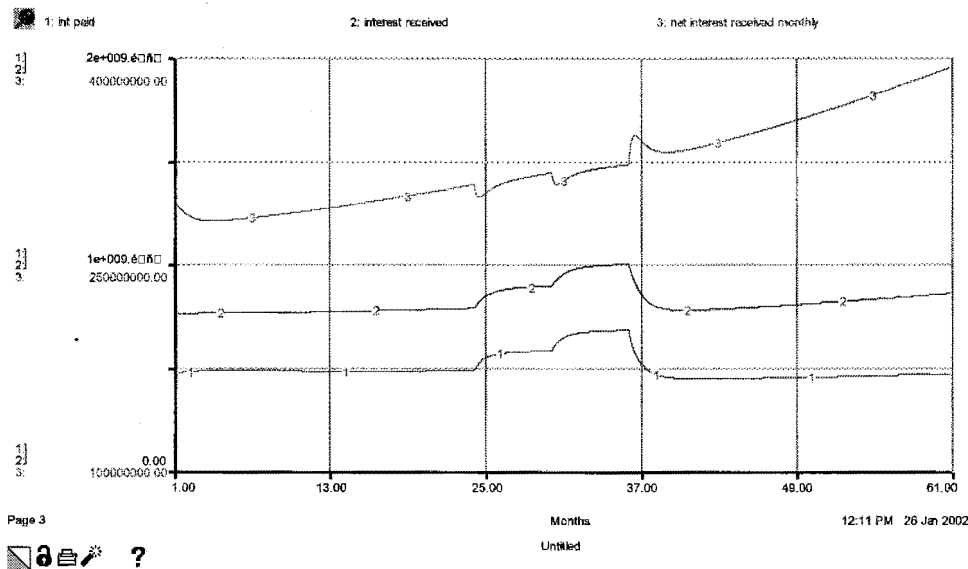
Figure 5.30

Bank 2: interest received and interest paid

1: int paid   2: interest received   3: net interest received monthly

Page 3   Months   12:13 PM 26 Jan 2002

Untitled
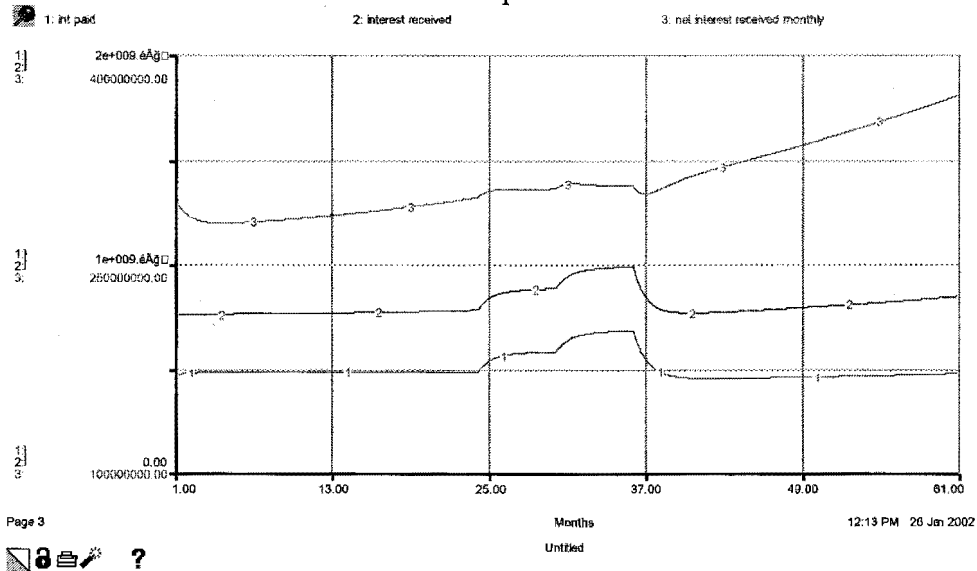
Comparison of the *net interest received monthly* for Bank 1 and Bank 2 shows clear difference with Bank 1 outperforming Bank 2 over the entire period. This is to be expected since Bank 1 has the competitive advantage in capabilities over Bank 2. However, the complementarity between resources through the effects of the feedback loops reinforces the growth experienced by Bank 1.

Figure 5.31 shows the comparative monthly *net income after tax* for both banks.

Figure 5.31

Bank 1 and 2: Comparison of monthly net income after tax

net income after tax: 1 - 2 -

Page 7   Months   01:15 PM 26 Jan 2002

Untitled
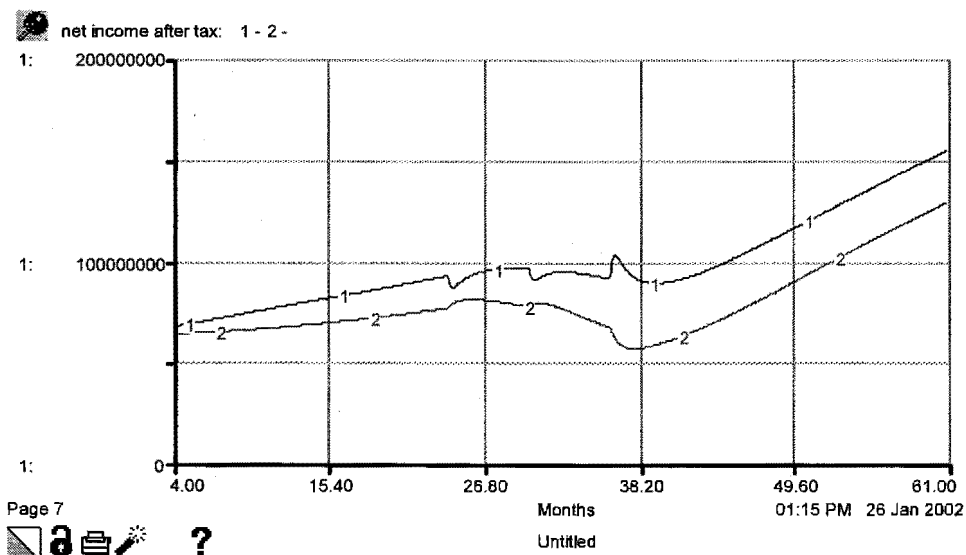
The differences in *net income after tax* can be ascribed to the capability differences, policy differences in asset and liability book structure as well as the complementarity between resources in the form of the feedback loops characteristic of this interest income generation system. The capability difference results in an increasing divergence between the monthly *net income after tax* for the two banks. The divergence is compounded during the volatile interest rate period between month 24 and 36 increasing the divergence due to the differences in the types of maturity mismatches of each bank.

This example illustrates that the performance of the bank cannot be ascribed to a single resource or competency. Rather, superior performance is the result of the combination of interconnected activities to produce a balanced set of resource accumulations, which generate superior financial performance [Markides: 2000]. Thus no single activity, such as a superior capability in attracting deposits, is responsible for the improved performance, but the systemic effects of the feedback loops through which policies and capabilities impact on the resource accumulations leads to superior performance.

5.9. Investigating Performance Differences for Banks with Identical Structures and Policies but Different Initial Resource Endowments.

We initiate the experiment for two identical banks with differing initial resource positions for retail deposits and performing advances but with identical policies and capabilities for guiding the resource flows under a dynamic interest rate environment. The initial positions of the two banks are identical except that bank 2 has a 20% larger deposits book than bank 1. The inflow of deposits is scaled relative to the size of the retail deposits book, implying an identical relative capability in attracting deposits. Both banks are exposed to the same interest rate scenario that is identical to the scenario described in section 5.8. - see figure 5.26.

Both banks are initialised with a long-funded position, i.e. have a maturity mismatch between long-dated liabilities and short dated assets exposing the bank to interest rate risk. This reflects the same policies applied to both banks. Both banks apply the same credit policies and experience identical default rates. We initialise the model with zero growth in monthly new retail deposits and monthly new performing advances and zero growth in non-interest income and operating expenses. This is done so as to ensure that the growth rate in theses variables do not confound the effect of the complementary resource structure in influencing performance.

Figure 5.32 illustrates the difference in net income before tax for bank1 and bank 2.

Figure 5.32

Bank 1 and 2: Comparison of total accumulated net income after tax

Total accum NIAT: 1 - 2 -
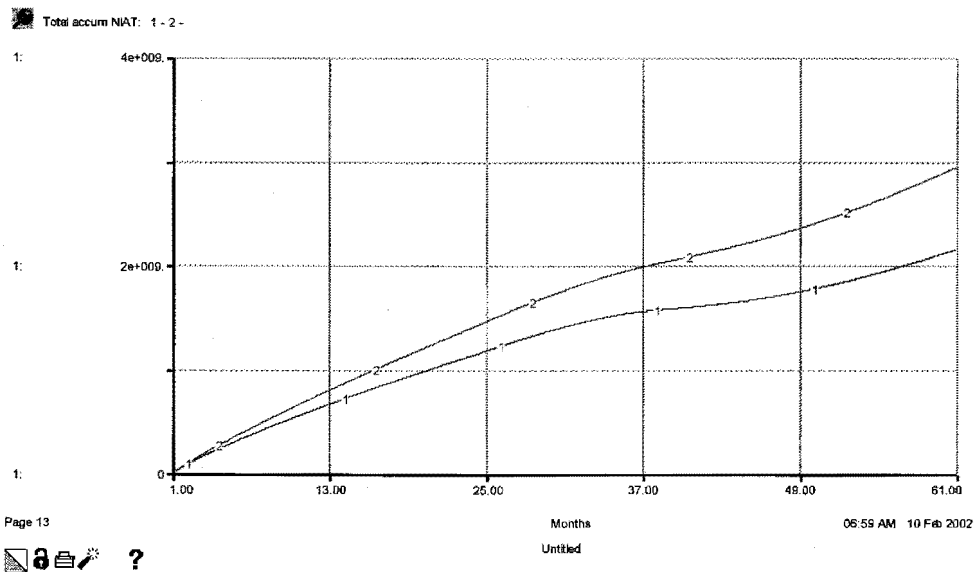
Bank 2, with its higher initial endowment of retail deposits rapidly develops a performance advantage despite all other policies and capabilities remaining identical between banks. This is driven by the complementarity between resources through the feedback loops. A higher level of deposits reduces the funding requirement that in turn reduces the interest paid, that in turn reduces the funding requirement further. The

reduction in funding requirement leads to a more rapid accumulation of tier 1 capital (see figure 5.33) reducing the funding requirement further.

━━━ Figure 5.33

Bank 1 and 2: Comparison of total capital accumulation
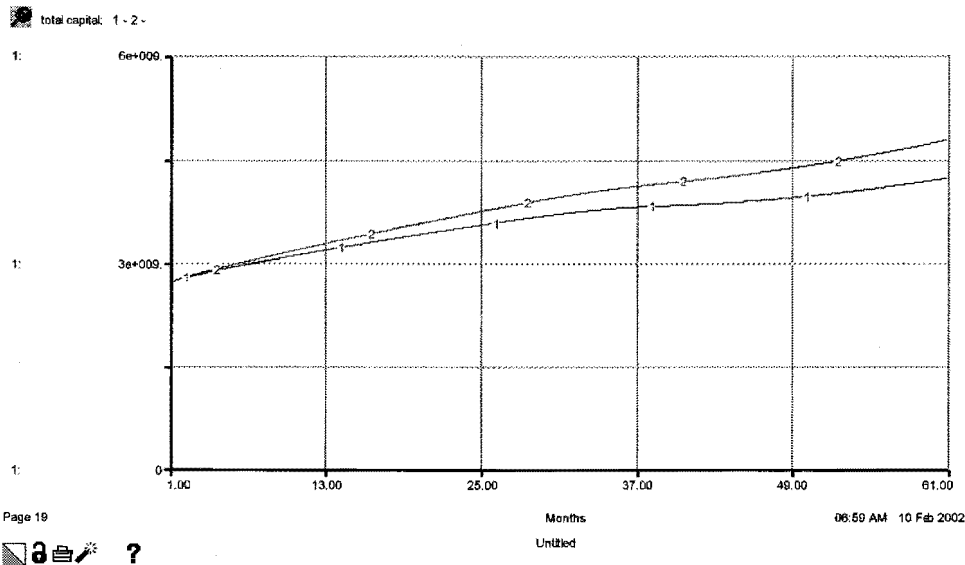
Figure 5.34 illustrates the difference in cost-to-income ratio for bank 1 and bank 2.

━━━ Figure 5.34

Comparative cost-to-income ratio
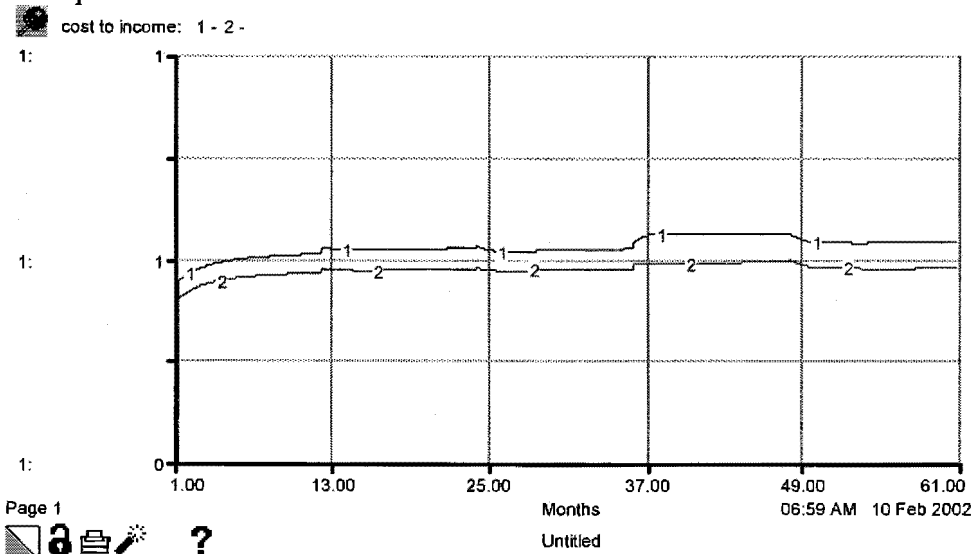
Clearly, the initial resource advantage of having higher levels of deposits translates into a better position in cost-to-income ratio.

Banks may have different levels of *retail deposits*. For example, retail banks in the United Kingdom are seldom short of funds and the deposits book often exceeds the advances book. In South Africa, by contrast, most of the retail banks are generally short of funds

requiring the banks to make up the shortfall in the money market or by lending from the Reserve Bank. However, in South Africa, smaller banks often have difficulty in attracting deposits, as investors perceive smaller banks to be more risky than larger "safe" banks. Such banks are at a definite disadvantage.

Bank 2 with a higher initial resource position in retail deposits has a definite advantage in the time evolution of its performance. We surmise that this initial resource advantage may be leveraged further. We investigate this by reducing the operating expenditure by 10% for both banks to test the comparative effect.

The differences in *cost-to-income ratio* under the two scenarios as at end year 5 are as follows:

_____ **Table 5.1**

Comparative cost-to-income ratios

	Bank 1	Bank 2
Base case scenario	0.655	0.624
20% reduction in operating expenditure	0.576	0.550
Gain in cost-to-income	12,1%	11,9%

The gain in cost-to-income ratio for bank 2 with the initial resource advantage in retail deposits is less than the gain in cost-to-income ratio for bank 2. This may seem to be a counter-intuitive result. We expected bank 2, with its resource advantage, to be advantaged again. However, there is a sound logic for this outcome; bank 1 with its lower level of retail deposits requires more funding. The funding rate is more expensive than the rate on deposits. With larger funding, funding plays a larger role in the performance outcomes. A reduction in funding has a larger overall impact for bank 2 than bank 1. The amount of gain is dependent on the level of retail deposits and the funding rate.

This leads to an important conclusion: an initial resource advantage provides a path dependent performance advantage [Morecroft: 2000], however, the bank with the initial resource disadvantage may obtain higher leverage from certain actions that have a greater impact than the resource advantaged bank. Thus, appropriate solutions or actions must be based on understanding the state of the resource system. Leverage points identified

for one resource system may not be the leverage point for a similar system with differing levels of resource endowments.

Smaller banks that have difficulty in attracting deposits due to higher perceived risk may have an advantage in being able to obtain greater leverage in cost-to-income ratio reduction than the more well-funded (deposit-taking) banks. Similarly, a cost reduction initiative for a highly funded South African bank may be more effective in reducing cost-to-income ratio than for a similar bank in the United Kingdom that has a surplus of deposits.

5.10. Path Dependencies

The last two sections have described how performance arises as a result of the initial resource endowments and complementarity between resources in the form of feedback loops. The resulting time paths of performance were resource constrained, that is, the time path of evolution of the resources cannot take any arbitrary form; its future behaviour is constrained by its current resource levels, capabilities and policies [Morecroft: 2000]. The firms current resource levels is itself a consequence of its past investments and policies. The implication is that to gain maximum performance out of the interest income generating system, managers must be able to design and manage a complex complementary resource system and understand where its leverage points are.

5.11. Leveraging the Resource System

The complementarity of the resources embedded in feedback loops make some actions more effective than others in improving system performance. To identify leverage points, (points of high influence) we conducted a sensitivity analysis for the interest income system based on our scenario for Bank 1 used in the above section, by varying each controllable or influenceable factor one-by-one by 10%, and measuring the net present value (NPV) of the *net income after tax* over the five-year period. A hurdle rate of 16% was assumed.

Table 5.2 shows the factors used, their base case, lower and upper values and the associated NPV.

━━ **Table 5.2**

Sensitivity analysis: Base resource system.

Variable	Base Value	Lower Value	Lower NPV Rand (Bn)	Upper Value	Upper NPV Rand (Bn)
Default rate	2.48% pa	2.23	2.678	2.73	3.239
Deposits growth	10% pa	9.0	2.919	11	2.997
Advances growth	10% pa	9.0	2.941	11	2.975
Opex growth	7% pa	6.3	2.788	7.7	3.123
Non-interest income	10% pa	9	2.772	11	3.149
Dividend policy	30%	27	2.941	33	2.974

The annual default rate showed the greatest impact for a 10% change in the variable. This appears to be by far the most sensitive variable. This has two implications; the variable may be a leverage point around which one may strategize and develop new policies to improve performance and, the sensitivity of the variable implies that we need to be fairly accurate about the relationships and parameter information in the credit loop. Because the variable is so sensitive, a small error in relationships or parameter values may lead to large errors. Thus, sensitivity analysis identifies aspects of the model that require further validation [Forrester: 1961].

The operating expenditure growth and non-interest income growth rate are both leverages as both variables impact directly on the "bottom line" and therefore on funding. These variables are potential leverages with high impact on performance. Having identified these variable, strategies may be formulated to use the levers to improve performance. However, there is one caveat; whilst the performance of the bank is a result of the way that the system is combined, and some actions are more effective than others in improving the resource system, the effectiveness of the actions are determined by the state that the resource system finds itself in. Thus, what may constitute an effective action for improving performance, today, may not be effective tomorrow despite the nature of the systemic structure being unchanged. This is because the level of resource endowments may have changed over time, altering the response of the system to certain actions. This implies that a resource system in its unique state requires unique solutions; copying best practice from similar firms may not be the best solution.

Note that the variables tested do not represent all the potential variables of the model. Due to time limitations of this dissertation of limited scope, extensive sensitivity testing was not conducted. This points towards further work required to understand the system more fully and to reveal other leverage points.

5.12. Summary

This section provides a summary of the insights gained with some potential policy implications.

The flows of the key resources are not only dependent on exogenous inputs such as interest rate movements but are highly dependent on the policies, capabilities and interdependencies linking resource accumulation:

- The flow of new advances is dependent on the current and recent history in the flow of new non-performing advances. This is operationalised in the form of the affordability factor that represents a policy choice of management. When new non-performing advances increase, the affordability factor is lowered by management (a policy choice) tightening the acceptance level of new advances. This represents an attempt to improve the future quality of the advances resource accumulation. The current state of the advances resource accumulation is a result of the historic rates of flow. This action may change the rates of flow of new advances instantaneously but cannot change the accumulation of the advances resource, nor the quality of the advances book (historic affordability) instantaneously. These resource accumulations can only be altered over time by the application of a consistent policy governing the inflows of the resource.
- The historic affordability is a key intangible resource, critical for the performance of the bank. The quality of new loans written defines the <u>future state</u> of the quality of the advances book. The current quality is a function of the <u>historic resource flows</u> and cannot be changed instantaneously. The historic quality of the loan book determines the minimum default rate currently experienced.
- The policies of management in building advances are aimed at a two-fold objective: to build the stock of performing advances over time and to minimise the outflow (leakage) of new non-performing advances. Building the stock of performing advances is generally achieved by maximising the inflow of new advances. Minimising the leakage of performing advances to non-performing advances is achieved by ensuring a high quality of advances book that may require a lower rate of inflow of new advances. Therefore, there may be conflicting objectives. This can be managed by understanding the interdependencies between resource accumulations and the impact of policies in a systemic way as this research attempts to show.
- A generally overlooked aspect of building performing advances is the impact of changing the rate of outflow of performing advances, that is, the rate of repayments and settlements. By slowing the outflow, the stock of advances is increased leading to a higher level of net interest received. This may be achieved by encouraging loan holders to extend a loan period.

- This lead to the following insight during the research (but not tested by the model due to time constraints) that it may be possible to increase the stock of performing advances by a combination of inflow and outflow management;
  - By encouraging the earlier repayment of an existing loan (increasing the outflow) so as to replace the loan with a new loan of higher capital value (increasing the inflow). This may be possible if one tracks the life-cycle stages of a home owner from the time of first home ownership, replacement with a second – more expensive home, etc. This may work particularly well for mortgage loans in a high inflationary environment.
- The resource accumulation of retail deposits is a key resource in determining the net income after tax. The rate of inflows of new deposits exceeds the rate of inflows of new advances, yet the retail deposits accumulation is far less than the performing advances accumulation. This is as a result of a more rapid outflow of retail deposits that depletes the deposits resource.
- The resource system, in equilibrium, demonstrates a lower performance position after experiencing interest rate shocks. This is due to the build-up of non-performing advances when interest rates rise, resulting in a build-up of the funding resource. This is true for all asset and liability term structures.
- The funding resource is a key resource enveloped within a strong negative feedback loop. The greater this resource accumulation, the higher the level of interest paid on this resource, reducing cash available that increases the required level of funding. This feedback loop has a significant impact on the path dependent evolution of the net income after tax for the interest income generating system. The effects of this feedback loop is generally not taken into consideration in the linear, non-systemic financial calculations of a bank thus obscuring the view as to why a performance advantage may arise.
- A linear increase in bad debt results in a non-linear change in performance as measured by the net interest received monthly. The non-linear change in performance is not fully explained by the loss in performing advances and loss in non-interest income. The reason is due to the strong funding feedback loop as discussed above.
- The tier 1 capital resource is increased or depleted by the positive or negative net income after tax position that feeds back into the funding loop. Thus there is significant complementarity between the retail deposits resource, the performing and non-performing advances, the historic affordability resource, the capital resource and the funding resource. This complementarity cannot be viewed from a linear perspective. The time dimension attached to all resource accumulations develops a performance advantage that reinforces itself. This makes it difficult for other banks to catch up with the initiator bank.
- From a resource system perspective, it is easy for managers to make short-term reallocations of cash to dividend payouts rather than to support funding reductions and tier 1 capital growth. The pressure to continue dividend growth may tempt managers to do so because they cannot alter the performance of the resource system in the very short term. Altering performance requires substantial changes to the levels of capital, funding, advances and deposits. Whilst resource flows can be changed instantaneously,

the accumulation of resources requires a continuous and persistent flow of resources over a sustained period of time, thus generally rendering managers helpless to alter performance in the short term. The pressure to improve investor payouts may result in the depletion of tier 1 capital and the unnecessary growth of funding leading to a poorer resource position over time damaging the interest income generating potential of the resource system.

- Two banks with identical structures and initial resource positions for the key resources (deposits, advances, funding, and capital, etc), but with different credit and asset and liability policies and capabilities will have different ending resource positions and performance. The resulting time paths of performance are resource constrained, that is, the time path of evolution of the key resources (deposits, funding, non-performing advances, etc) cannot take any arbitrary form; its future development is constrained by the current state of resource levels, as well as the capabilities and policies of the bank (asset and liability management, credit management, etc).

- Two banks with identical structures and policies and capabilities but with differing initial resource positions will have different path dependent performance time paths. The bank with the superior resource position (e.g. higher levels of deposits, lower levels of funding and non-performing advances) will develop a path dependent performance advantage.

- However, in some cases, the bank with the initial resource disadvantage may obtain a higher leverage from certain actions. This was observed with our bank with the inferior deposit position and higher cost-to-income ratio that leveraged expenditure cuts to obtain a greater gain in cost-to-income ratio per reduced unit expenditure.

- This leads us on to the view that whilst the performance of the bank is a result of the way that the system is combined, some actions are more effective than others in improving the resource system. The effectiveness of the actions are determined by the state that the resource system finds itself in. Thus, what may constitute an effective leverage for improving performance, today, may not be effective tomorrow despite the nature of the systemic structure being unchanged. This is because the level of resource endowments may have changed over time, altering the response of the system to certain actions. This attests to the view of Morecroft and Warren that a resource system in its unique state requires unique solutions.

- Identified leverages for the resource system in its state as described in this chapter are the annual default rate, non-interest income and operating expenditure. These leverages are unique to the state of the resources system and may change over time as the resource levels evolve.

Chapter 6

Conclusion

6.1. Introduction.

This final chapter serves a number of purposes. First we summarise the evidence in support of the initial position adopted in arguing that the complexities of a bank interest income generating system justifies the use of a more complex systemic and dynamic framework. Following that we provide a summary of the insights gained from the investigation. A critique of this research effort is then given based on the perceived shortcomings and gaps that exist. Next, the methodology is placed into perspective relative to other approaches and improvements and future directions in terms of this research are discussed. Finally, the contributions of this work are identified.

6.2. In Support of the central Thesis

The central thesis of this research is that the dynamic behaviour of the interest income generation of a typical retail bank arises as much from the exogenous inputs such as interest rates to the resource system as from the interactions of the decision agents (credit, asset and liability management, etc) and resource flows in the bank. Thus the dynamic interest income behaviour is dependent on an internal, systemic structure. We offer the following evidence obtained from the research in support of this thesis:

The systemic feedback structure with resource accumulations and policies of the decision agents replicated the performance experienced by the retail bank over the period 1 April 1995 to 31 March 2000 given the same exogenous environmental factors (advances and deposit growth rates, interest rates). This provides one point of contact with the behaviour of the actual system developing a measure of confidence in the validity of the model as a means of explaining the performance.

Within the system as bounded for this research, there is a systemic feedback structure consisting of several feedback loops that attempt to keep the system resource accumulations in balance so as to ensure a sustainable increase in net income after tax. The major loops are the credit balancing loops to control the annual default rate, the credit balancing loop to control new advances so as to minimise the growth in non-performing advances, the funding loop, the capital adequacy loop and retained earnings-funding loop. Other derivatives of these loops also exist. The credit loops and retained earnings funding loops are policy loops under control of management. Different policies produce a different evolutionary performance of net income after tax.

The key resource accumulations upon which the interest income performance is dependent upon are the performing advances, the non-performing advances, the deposits accumulation, the funding resource, tier 1 and tier 2 capital accumulations and the quality of the loan book (historic affordability). The resource flows are governed by the capabilities and policies of management.

The complexity and interconnectedness of a bank's interest income generating system results in path dependent evolution of performance constrained by the initial resource endowments of the interest income generating resource system. The framework allows one to investigate the evolution of path dependent performance that few other approaches allow. This justifies the use of a more complex systemic and dynamic framework for understanding how interest income arises.

6.3.   General Insights Obtained about the Resource System.

There is path dependent evolution of performance based on the state of the key resources. Thus, the interest paid and interest received are drivers for the interest income of a bank these, in turn, are dependent on the state of the key resources that themselves are dependent on the complementarity between the key resource accumulations.

The following two insights confirm the general conclusions by Warren about dynamic resource systems [Warren: 1999]:

- Given two banks with identical key resources and initial levels for the key resources, and identical exogenous interest rate environments, the differences in path evolution of net income after tax can be shown to be due to the credit policies, asset & liability management policies, superior capabilities in attracting deposits, loans and funding and superior capabilities in cost management. The capability differences do not need to be large, but due to the complementarity of the resource structure, will result in significantly different path dependent evolution of key resource accumulations giving rise to superior net income after tax performance.

- Alternatively, given identical structures, policies and capabilities, differences in the evolution of net income after tax are due to initial states of the key resource accumulations. Complementarity of the resource structure again ensures different path dependent evolutionary performances. The current state of a bank's interest income generating resource system is the result of all historic flow rates, policies and capabilities and constrains the path of evolution of future performance. Thus the evolution of the resource accumulations are path dependent, i.e. dependent on its current resource state. With different initial conditions, different path dependent evolution of net income after tax arises.

6.4. Gaps in the research, knowledge and methods

6.4.1. Gaps in data:

Much of the financial data required for this research was documented and available. However, as soon as one moves outside the realm of financial information, data sources become far more difficult to source and the data itself is flimsy and often held in disparate sources making it difficult to trace. Thus, for example, the historic affordability of different client segments is not readily available. Similarly the relationship between the client repayment ratio and the debt stress multiplier is not recorded. Such relationships generally do not feature in the management recording systems of a firm. Under such conditions, we interviewed knowledgeable executives, inferred relationships from data and "triangulated" or approximated data from analogous situations. Similarly, "hard" data such as the average outstanding loan term are not recorded automatically. Such variables are easier to estimate but also represent gaps in our data. Much further work will be required before we are certain about the parameters, values and relationships assumed in this model.

6.4.2. Gaps in structural knowledge

Conceptualising the resource structure and feedback loops of a business requires one to translate perceived causal relationships into a structural framework. The lack of data often makes it impossible to verify the hypothesised relationship. Various individuals may also have diverse views on the nature of the causality as well as the direction of causality. The credit loops pose the greatest challenge in terms of structure and data. This is a definite area in which behavioural and structural knowledge is lacking.

6.4.3. Gaps in validation

The tests for suitability of model behaviour were conducted by comparison of simulated results with reported results. However, these tests were conducted under changing environmental conditions for interest rates, advances growth and deposits growth. This tested the response of the system to these variables. There are many other scenarios where other variables (for example, a change in average gross salary of the client base) may change with time. Such scenarios provide additional points of contact with reality. However, if such scenarios have not previously occurred, no reported data will be available as reference points to test the simulation against. Thus, validation of the model is conditional and limited to those points of contact with reality that can be established without unreasonable amounts of time and effort.

6.5. Improvements and Future Directions

In this section we extend our knowledge to make connections beyond the boundaries of this particular research project. The intention is to provide some perspectives that could guide further research directions.

The aim of this dissertation has been to develop a resource-based systemic and dynamic view of the interest income generation structure of a typical retail bank that will allow us to test our dynamic hypothesis about the causes of observed transient behaviour and explain the dynamic behaviour from a complex feedback perspective. Whilst the model does support the objective, one can argue that there are many more

pertinent factors, that are taken as given, i.e. background information, but that may shed additional light on the performance of the interest income generating system of a bank. Thus several extensions can be proposed.

Our main argument is that performance arises as a result of the accumulation of key resources of advances, deposits, funding, quality of the loan book, etc. Whilst this holds true for our model, the boundary of the model does not draw wide enough to explain fully how competitive advantage arises for the interest income generation system of a bank. If we view the bank from a product-market perspective, that is, the bank is rooted in its market environment, then we can argue that other resources such as the number of outlets that a bank has would affect the fraction of its target market clients that it could reach. Such a resource would be a key resource for understanding how new advances and new deposits arise (currently an exogenous input) leading to competitive advantage. It is a principle of system dynamics that one cannot model the entire system, but only model those aspects that are relevant to answering a particular question. With this in mind, opening the boundary of the model would necessitate a re-visit of the objective of the model to perhaps encompass the understanding of competitive advantage rather than performance. However, such insights may be very rewarding in terms of new understanding gained.

A second consideration in drawing the boundary wider to include a product-market perspective would be to acknowledge the fact that banks operate in a competitive environment for the attention of clients in desired market segments. Thus, to attain a better understanding of how competitive advantage arises, rivalry will have to be taken into account for all resources that banks compete for. This may include, clients, intellectual capital, funding, etc.

A third aspect that may provide further insight, considered as a given in this model, is the structure of an objectives hierarchy for the bank and the incentives in place that support or do not support the objectives, leading to a conflicting objectives scenario. This has been evident in some banking catastrophes such as the Unifer Bank debacle, where incentives existed to maximise new advances, in conflict with the objectives of attaining sustainable performance over time [Finance Week: 2002]. Overlaying and modelling the incentive structures may provide powerful insight into the performance of the system and guide the development of appropriate incentive structures to guide the implementation of appropriate policies.

Virtually all aspects of the model can be refined to a higher degree of sophistication. The development of a system dynamics simulation model requires an understanding of the causal system underpinning performance as well as the nature of the relationships in quantitative form. This view is not a conventional one in most organizations, leading to a dearth of quantitative information over the time period of history, simply because it has never been required to be measured. For example, the historic affordability is a measure of the quality of the book. How many loans have been offered at what affordability level is not monitored or tracked. This leads to difficulties in inferring a suitable conceptual modelling structure. Nevertheless, to move our understanding forward, we need to start with an initial hypothesis and use the best information available to assist. Further research needs to be undertaken

particularly around our understanding of the credit default issue from a systemic perspective. One suggested method might be to identify the key measures required and to track those measures quantitatively over an extended period of time within a bank as a part of the executive performance management system. Only by having an initial systemic structure will we be able to interpret the information streams and improve upon our learning about how such systems function.

The credit assessment process has become very sophisticated over the last few years. This sophistication has not been included in the model and may provide new insights if included in the model.

The asset and liability management has not considered the impact of modern financial derivative instruments as a means of hedging. Including these aspects will increase the sophistication of the model.

Investigation of alternative policy designs is an area that has not been explored in this research. The use of alternative sources of information in the credit policies is a potential area of research. Information sources such as interest rate movements rather than information about non-performing advances may lead to different responses in system behaviour and performance under volatile interest rate regimes.

Finally, the frequency response of the system given a cyclical interest rate environment can be explored. The intention being to understand how the system responds to interest rate cycles with varying frequencies and amplitudes, to investigate whether the systems exhibits a natural frequency and whether such natural frequency is close to the frequency of the typical South African interest rate cycle.

6.6. The Contribution of this Research
The primary contribution of this research lies in the systematic and systemic abstraction of the interest income generating structure of a typical retail bank, the development of a quantitative model of limited scope and the insights obtained from this.

The model developed may be considered to be a generic model applicable to any bank with a similar structure but with different objectives, parameter values, resource levels, policy parameters and exogenous inputs and provides different performance time paths with the same structure.

The insights about solutions and leverage points are specific to the state of the interest income generating resource system and are thus time dependent. This provides an insight that traditional static banking models do not provide by identifying specific leverages applicable at specific time frames and valid for specific durations over which the banking resource system evolves.

The model captures the major causal relationships and feedback loops of the interest income generating system and provides a basis for understanding the path dependent evolution of the interest income performance of the bank. This is in contrast to the linear and open ended planning tools that are prevalent in the modern bank. Tools

such as spreadsheets allow for any values to be inserted in the model for variables such as advances growth, default rate, etc providing a forecast of net income after tax without inferring how path dependent evolution of performance arises.

The framework has allowed us to interpret existing information about the interest income generating system of a bank in a new way, giving rise to insights about how such a structure evolves and how we may be able to improve the time evolution of performance. From a strategic planning perspective, this kind of model provides a means of establishing the medium to long-term impact of alternative actions without the use of data intensive models. This allows strategists to quickly come to grips with the underlying structure, path dependent evolution of performance and leverage points to improve performance. Whilst this kind of model only produces trends, it is sufficient to produce insight and foresight into which actions may be effective and which not.

Appendix A

Model Source Code for Chapter 3.

Advances Sector

non_performing_advances(t) = non_performing_advances(t - dt) +
(new_non_perf_advances - bad_debt - recoveries) * dt
INIT non_performing_advances = 0.0065*performing_advances
INFLOWS:
new_non_perf_advances = performing_advances*annual_default_rate/1200
OUTFLOWS:
bad_debt = non_performing_advances/time_to_writeoff
recoveries = non_performing_advances*writeoff_impact_on_recoveries/12
performing_advances(t) = performing_advances(t - dt) + (new_advances -
repayments_and_settlement - new_non_perf_advances) * dt
INIT performing_advances = 53.276e009
INFLOWS:
new_advances = (advances_growth*acceptance_rate)
OUTFLOWS:
repayments_and_settlement = performing_advances/ave_loan_duration
new_non_perf_advances = performing_advances*annual_default_rate/1200
bad_debt_ratio = (bad_debt/total_advances)*100
percent_of_adv = (non_performing_advances/total_advances)*100
time_to_writeoff = 12+step(0,12)
total_advances = non_performing_advances+performing_advances
advances_growth = GRAPH(TIME)
(1.00, 1.2e+009), (6.36, 1.3e+009), (11.7, 1.5e+009), (17.1, 1.4e+009), (22.5,
1.4e+009), (27.8, 1.5e+009), (33.2, 1.6e+009), (38.5, 1.6e+009), (43.9, 1.6e+009),
(49.3, 1.4e+009), (54.6, 1.3e+009), (60.0, 1.3e+009)
writeoff_impact_on_recoveries = GRAPH(time_to_writeoff)
(0.00, 0.00), (1.20, 0.0188), (2.40, 0.0268), (3.60, 0.0338), (4.80, 0.0374), (6.00, 0.04),
(7.20, 0.04), (8.40, 0.04), (9.60, 0.04), (10.8, 0.04), (12.0, 0.04)

Bank Rates

funding_rate(t) = funding_rate(t - dt) + (change_in_funding_rate) * dt
INIT funding_rate = 13
INFLOWS:
change_in_funding_rate = (market_rate-funding_rate)/time_to_adjust_funding_rate
rate_on_advances(t) = rate_on_advances(t - dt) + (change_in_adv_rate) * dt
INIT rate_on_advances = 19
INFLOWS:
change_in_adv_rate = ((market_rate+markup)-
rate_on_advances)/time_to_adjust_rate

rate_on_deposits(t) = rate_on_deposits(t - dt) + (change_in_dep_rate) * dt
INIT rate_on_deposits = 12
INFLOWS:
change_in_dep_rate = ((market_rate-dep_margin)-
rate_on_deposits)/time_to_adjust_dep_rate
dep_margin = 3.69
time_to_adjust_dep_rate = 0.75
time_to_adjust_funding_rate = 1
time_to_adjust_rate =
IF(TREND(rate_on_advances,2,0)*100>=0)THEN(0.25)ELSE(0.1)
markup = GRAPH(TIME)
(1.00, 4.40), (6.90, 4.17), (12.8, 4.08), (18.7, 3.95), (24.6, 3.93), (30.5, 3.93), (36.4,
3.93), (42.3, 4.00), (48.2, 4.05), (54.1, 3.78), (60.0, 3.78)

Capital Sector

tier_1_capital(t) = tier_1_capital(t - dt) + (equity_issue + retained_earnings) * dt
INIT tier_1_capital = 2172.9e006
INFLOWS:
equity_issue = 0
retained_earnings = net_income_after_tax-dividends
tier_2_capital(t) = tier_2_capital(t - dt) + (new_loan_capital - capital_redemption) *
dt
INIT tier_2_capital = 547.1e006
INFLOWS:
new_loan_capital = GRAPH(TIME)
(1.00, 1.5e+007), (6.90, 1.5e+007), (12.8, 1.5e+007), (18.7, 3.8e+007), (24.6,
3.8e+007), (30.5, 3.8e+007), (36.4, 5e+007), (42.3, 5e+007), (48.2, 4.9e+007), (54.1,
3.9e+007), (60.0, 3.9e+007)
OUTFLOWS:
capital_redemption = tier_2_capital/cap_redemption_period
cap_redemption_period = 36
cap_to_RWA = total_capital/risk_weighted_assets
CAR = 0.08
CAR_max_advances = total_capital/CAR
risk_weighted_assets = total_advances*0.5
total_capital = tier_1_capital+tier_2_capital

Credit sector

affordability_factor(t) = affordability_factor(t - dt) + (delta_afford_factor) * dt
INIT affordability_factor = 0.33
INFLOWS:
delta_afford_factor = (affordability_impact-affordability_factor)/t_for_afford_factor
annual_default_rate(t) = annual_default_rate(t - dt) + (delta_default) * dt
INIT annual_default_rate = impending_default
INFLOWS:
delta_default = (impending_default-annual_default_rate)/t_for_default
historic_affordability(t) = historic_affordability(t - dt) + (delta_historic_afford) * dt
INIT historic_affordability = 0.3

INFLOWS:
delta_historic_afford = (affordability_impact-
historic_affordability)/ave_loan_duration
perceived_new_NPA's(t) = perceived_new_NPA's(t - dt) + (delta_perc_NPA) * dt
INIT perceived_new_NPA's = new_NPA_ratio*100
INFLOWS:
delta_perc_NPA = ((new_NPA_ratio*100)-
perceived_new_NPA's)/t_for_new_NPA_growth
ave_current_repayment =
ave_loan_size/(((($1+$(rate_on_advances/1200))$ \wedge $ave_outstanding_loan_term)-
$1)/((rate_on_advances/1200)*(1+(rate_on_advances/1200))$ \wedge $ave_outstanding_loan_t
erm))
ave_default = 1
ave_gross_salary = 9000
ave_loan_duration = 84-step(0,12)
ave_outstanding_loan_term = 240-ave_loan_duration
impending_default = min_default+ave_default*debt_stress_multiplier
max_desired_repay = ave_gross_salary*prudence_factor
new_NPA_ratio = (non_performing_advances/performing_advances)
prudence_factor = 0.3
repayment_ratio = ave_current_repayment/max_desired_repay
t_for_afford_factor = IF(TREND(affordability_factor,2,0)<0)THEN(2)ELSE(2000)
t_for_default = 3
t_for_new_NPA_growth = 3
acceptance_rate = GRAPH(affordability_factor)
(0.2, 0.9), (0.213, 0.905), (0.226, 0.91), (0.239, 0.915), (0.252, 0.922), (0.265, 0.929),
(0.278, 0.936), (0.291, 0.947), (0.304, 0.96), (0.317, 0.976), (0.33, 1.00)
affordability_impact = GRAPH(perceived_new_NPA's)
(0.65, 0.33), (0.78, 0.33), (0.91, 0.33), (1.04, 0.33), (1.17, 0.325), (1.30, 0.302), (1.43,
0.263), (1.56, 0.255), (1.69, 0.253), (1.82, 0.252), (1.95, 0.25)
debt_stress_multiplier = GRAPH(repayment_ratio)
(0.00, 0.00), (0.05, 0.00), (0.1, 0.045), (0.15, 0.09), (0.2, 0.075), (0.25, 0.09), (0.3, 0.09),
(0.35, 0.09), (0.4, 0.105), (0.45, 0.12), (0.5, 0.135), (0.55, 0.15), (0.6, 0.165), (0.65,
0.25), (0.7, 0.35), (0.75, 0.45), (0.8, 0.65), (0.85, 0.95), (0.9, 1.40), (0.95, 2.40), (1.00,
6.95)
min_default = GRAPH(historic_affordability)
(0.25, 0.25), (0.258, 0.25), (0.266, 0.255), (0.274, 0.26), (0.282, 0.267), (0.29, 0.274),
(0.298, 0.28), (0.306, 0.288), (0.314, 0.295), (0.322, 0.3), (0.33, 0.3)

Deposit client sector
retail_deposits(t) = retail_deposits(t - dt) + (new_deposits - withdrawls) * dt
INIT retail_deposits = 40.142e009
INFLOWS:
new_deposits = deposits_growth_DG
OUTFLOWS:
withdrawls = retail_deposits/time_to_withdraw
time_to_withdraw = 18

deposits_growth_DG = GRAPH(TIME)
(1.00, 2.7e+009), (3.57, 2.8e+009), (6.13, 2.9e+009), (8.70, 2.9e+009), (11.3,
3e+009), (13.8, 3.1e+009), (16.4, 3.2e+009), (19.0, 3.2e+009), (21.5, 3.3e+009),
(24.1, 3.4e+009), (26.7, 3.5e+009), (29.2, 3.6e+009), (31.8, 3.7e+009), (34.3,
3.7e+009), (36.9, 3.8e+009), (39.5, 3.5e+009), (42.0, 3.2e+009), (44.6, 3.1e+009),
(47.2, 3.1e+009), (49.7, 3.2e+009), (52.3, 3.3e+009), (54.9, 3.5e+009), (57.4,
3.8e+009), (60.0, 4.2e+009)

Financial sector

book_value_of_fixed_assets(t) = book_value_of_fixed_assets(t - dt) +
(investment_in_fixed_assets - depreciation) * dt
INIT book_value_of_fixed_assets = 278.4e006
INFLOWS:
investment_in_fixed_assets = 10e006
OUTFLOWS:
depreciation = book_value_of_fixed_assets/depreciation_period
bad_&_doubtful_advances = bad_debt
depreciation_period = 60
interest_income = total_advances*rate_on_advances/1200
interest_on_loan_cap = tier_2_capital*loan_cap_rate/1200
int_on_deposits = (retail_deposits)*rate_on_deposits/1200
int_paid = int_on_deposits+int_paid_on_funding+interest_on_loan_cap
int_paid_on_funding = funding*funding_rate/1200
loan_cap_rate = 11
net_income_after_tax = net_income_before_tax-tax
net_income_before_tax = operating_income-operating_expenses
net_interest_income = interest_income-int_paid
net_interest_margin = (net_interest_income/total_advances)*100*12
NPV_NIAT = NPV(net_income_after_tax,0.18/12,0)
operating_expenses = depreciation+(other_expenses)
operating_income = total_income-bad_&_doubtful_advances+prof_share
prof_share =
0+pulse(133.6e006,11,0)+pulse(167.4e006,23,0)+pulse(199e006,35,0)+pulse(210e0
06,47,0)+pulse(325e006,59,0)
tax =
IF(net_income_before_tax<=0)THEN(0)ELSE(net_income_before_tax*tax_rate/10
0)
tax_rate = 43+step(-3,12)+step(-5,24)+step(-5,48)
total_income = net_interest_income+(non_interest_income)
non_interest_income = GRAPH(TIME)
(1.00, 8.9e+007), (2.00, 8.9e+007), (3.00, 8.9e+007), (4.00, 8.9e+007), (5.00,
8.9e+007), (6.00, 8.9e+007), (7.00, 8.9e+007), (8.00, 8.9e+007), (9.00, 8.9e+007),
(10.0, 8.9e+007), (11.0, 8.9e+007), (12.0, 8.9e+007), (13.0, 1.1e+008), (14.0,
1.1e+008), (15.0, 1.1e+008), (16.0, 1.1e+008), (17.0, 1.1e+008), (18.0, 1.1e+008),
(19.0, 1.1e+008), (20.0, 1.1e+008), (21.0, 1.1e+008), (22.0, 1.1e+008), (23.0,
1.1e+008), (24.0, 1.1e+008), (25.0, 1.3e+008), (26.0, 1.3e+008), (27.0, 1.3e+008),
(28.0, 1.3e+008), (29.0, 1.3e+008), (30.0, 1.3e+008), (31.0, 1.3e+008), (32.0,
1.3e+008), (33.0, 1.3e+008), (34.0, 1.3e+008), (35.0, 1.3e+008), (36.0, 1.3e+008),

(37.0, 1.6e+008), (38.0, 1.6e+008), (39.0, 1.6e+008), (40.0, 1.6e+008), (41.0, 1.6e+008), (42.0, 1.6e+008), (43.0, 1.6e+008), (44.0, 1.6e+008), (45.0, 1.6e+008), (46.0, 1.6e+008), (47.0, 1.6e+008), (48.0, 1.6e+008), (49.0, 1.9e+008), (50.0, 1.9e+008), (51.0, 1.9e+008), (52.0, 1.9e+008), (53.0, 1.9e+008), (54.0, 1.9e+008), (55.0, 1.9e+008), (56.0, 1.9e+008), (57.0, 1.9e+008), (58.0, 1.9e+008), (59.0, 1.9e+008), (60.0, 1.9e+008)
other_expenses = GRAPH(TIME)
(1.00, 2.9e+008), (2.00, 2.9e+008), (3.00, 2.9e+008), (4.00, 2.9e+008), (5.00, 2.9e+008), (6.00, 2.9e+008), (7.00, 2.9e+008), (8.00, 2.9e+008), (9.00, 2.9e+008), (10.0, 2.9e+008), (11.0, 2.9e+008), (12.0, 2.9e+008), (13.0, 3.4e+008), (14.0, 3.4e+008), (15.0, 3.4e+008), (16.0, 3.4e+008), (17.0, 3.4e+008), (18.0, 3.4e+008), (19.0, 3.4e+008), (20.0, 3.4e+008), (21.0, 3.4e+008), (22.0, 3.4e+008), (23.0, 3.4e+008), (24.0, 3.4e+008), (25.0, 3.8e+008), (26.0, 3.8e+008), (27.0, 3.8e+008), (28.0, 3.8e+008), (29.0, 3.8e+008), (30.0, 3.8e+008), (31.0, 3.8e+008), (32.0, 3.8e+008), (33.0, 3.8e+008), (34.0, 3.8e+008), (35.0, 3.8e+008), (36.0, 3.8e+008), (37.0, 4.1e+008), (38.0, 4.1e+008), (39.0, 4.1e+008), (40.0, 4.1e+008), (41.0, 4.1e+008), (42.0, 4.1e+008), (43.0, 4.1e+008), (44.0, 4.1e+008), (45.0, 4.1e+008), (46.0, 4.1e+008), (47.0, 4.1e+008), (48.0, 4.1e+008), (49.0, 4.4e+008), (50.0, 4.4e+008), (51.0, 4.4e+008), (52.0, 4.4e+008), (53.0, 4.4e+008), (54.0, 4.4e+008), (55.0, 4.4e+008), (56.0, 4.4e+008), (57.0, 4.4e+008), (58.0, 4.4e+008), (59.0, 4.4e+008), (60.0, 4.4e+008)

Funding sector
funding(t) = funding(t - dt) + (delta_fund) * dt
INIT funding = 14.269e009
INFLOWS:
delta_fund = change_in_funding_required
change_in_funding_required = new_advances-repayments_and_settlement-recoveries-new_deposits+withdrawls-net_interest_received_monthly+tax+other_expenses-non_interest_income+investment_in_fixed_assets+dividends-equity_issue+change_in_liquids-new_loan_capital+capital_redemption
interest_received = performing_advances*rate_on_advances/1200
net_interest_received_monthly = interest_received-int_paid

General Calculations Sector
accum_cti(t) = accum_cti(t - dt) + (monthly_cti_in - annual_cti_out) * dt
INIT accum_cti = 0
INFLOWS:
monthly_cti_in = cost_to_income
OUTFLOWS:
annual_cti_out = PULSE(accum_cti,12,12)
annual_accumulated_profit_share(t) = annual_accumulated_profit_share(t - dt) + (monthly_profi_share_in - annual_profit_share_out) * dt
INIT annual_accumulated_profit_share = 1
INFLOWS:
monthly_profi_share_in = prof_share
OUTFLOWS:

annual_profit_share_out = PULSE(annual_accumulated_profit_share,12,12)
annual_bad_&_doubtful_advances(t) = annual_bad_&_doubtful_advances(t - dt) +
(monthly_B&D_in - annual_B&D_out) * dt
INIT annual_bad_&_doubtful_advances = 0
INFLOWS:
monthly_B&D_in = bad_&_doubtful_advances
OUTFLOWS:
annual_B&D_out = PULSE(annual_bad_&_doubtful_advances,12,12)
annual_depreciation_charge(t) = annual_depreciation_charge(t - dt) +
(monthly_depreciation_in - annual_depreciation_out) * dt
INIT annual_depreciation_charge = 0
INFLOWS:
monthly_depreciation_in = depreciation
OUTFLOWS:
annual_depreciation_out = PULSE(annual_depreciation_charge,12,12)
annual_dividends(t) = annual_dividends(t - dt) + (monthly_dividends_in -
annual_dividends_out) * dt
INIT annual_dividends = 0
INFLOWS:
monthly_dividends_in = dividends
OUTFLOWS:
annual_dividends_out = PULSE(annual_dividends,12,12)
annual_int_on_loan_cap(t) = annual_int_on_loan_cap(t - dt) +
(monthly_loan_cap_int_in - annual_loan_cap_int_out) * dt
INIT annual_int_on_loan_cap = 0
INFLOWS:
monthly_loan_cap_int_in = interest_on_loan_cap
OUTFLOWS:
annual_loan_cap_int_out = PULSE(annual_int_on_loan_cap,12,12)
Annual_NIAT(t) = Annual_NIAT(t - dt) + (monthly_NIAT_in -
annual_NIAT_out) * dt
INIT Annual_NIAT = 0
INFLOWS:
monthly_NIAT_in = net_income_after_tax
OUTFLOWS:
annual_NIAT_out = PULSE(Annual_NIAT,12,12)
annual_NIBT(t) = annual_NIBT(t - dt) + (monthly_NIBT_in -
annual_NIBT_out) * dt
INIT annual_NIBT = 0
INFLOWS:
monthly_NIBT_in = net_income_before_tax
OUTFLOWS:
annual_NIBT_out = PULSE(annual_NIBT,12,12)
annual_NII(t) = annual_NII(t - dt) + (monthly_NII_in - annual_NII_out) * dt
INIT annual_NII = 1
INFLOWS:
monthly_NII_in = net_interest_income
OUTFLOWS:

annual_NII_out = PULSE(annual_NII,12,12)

annual_non_interest_income(t) = annual_non_interest_income(t - dt) +
(monthly_non_int_income_in - annual_non_int_income_out) * dt

INIT annual_non_interest_income = 1

INFLOWS:

monthly_non_int_income_in = non_interest_income

OUTFLOWS:

annual_non_int_income_out = PULSE(annual_non_interest_income,12,12)

annual_operating_expenses(t) = annual_operating_expenses(t - dt) +
(monthly_operating_expenses_in - annual_operating_expenses_out) * dt

INIT annual_operating_expenses = 0

INFLOWS:

monthly_operating_expenses_in = operating_expenses

OUTFLOWS:

annual_operating_expenses_out = PULSE(annual_operating_expenses,12,12)

annual_operating_income(t) = annual_operating_income(t - dt) +
(monthly_oper_income_in - annual_op_income_out) * dt

INIT annual_operating_income = 0

INFLOWS:

monthly_oper_income_in = operating_income

OUTFLOWS:

annual_op_income_out = PULSE(annual_operating_income,12,12)

asset_yield = total_income/book_value_of_fixed_assets

ave_cost_to_income = accum_cti/12

cost_to_income =
annual_operating_expenses/(annual_NII+annual_non_interest_income+annual_acc
umulated_profit_share)

primary_funding = total_advances-retail_deposits

Profit_margin = net_income_after_tax/total_income

ROA2 = Profit_margin*asset_yield

total_assets = book_value_of_fixed_assets+performing_advances+liquid_assets

total_liabilities = funding+retail_deposits+tier_1_capital+tier_2_capital

Liquids sector

liquid_assets(t) = liquid_assets(t - dt) + (change_in_liquids) * dt

INIT liquid_assets = 2681.4e006

INFLOWS:

change_in_liquids = (retail_deposits*liquid_asset_fraction)-liquid_assets

liquid_asset_fraction = GRAPH(TIME)

(1.00, 0.105), (6.90, 0.105), (12.8, 0.11), (18.7, 0.15), (24.6, 0.15), (30.5, 0.105), (36.4, 0.105), (42.3, 0.105), (48.2, 0.11), (54.1, 0.11), (60.0, 0.11)

Loan client sector

loans_in_force(t) = loans_in_force(t - dt) + (loan_sales - settled_loans) * dt

INIT loans_in_force = 500000

INFLOWS:

loan_sales = new_advances/ave_new_loan_size

OUTFLOWS:

settled_loans =
(new_non_perf_advances+repayments_and_settlement)/ave_loan_size
ave_loan_size = smth1(performing_advances/loans_in_force,1)
ave_new_loan_size = 150000

Market rates
market_rate = GRAPH(TIME)
(1.00, 13.7), (2.00, 13.9), (3.00, 13.9), (4.00, 14.2), (5.00, 14.4), (6.00, 14.4), (7.00, 14.5), (8.00, 14.5), (9.00, 14.7), (10.0, 14.6), (11.0, 14.5), (12.0, 14.5), (13.0, 14.4), (14.0, 15.0), (15.0, 15.4), (16.0, 15.4), (17.0, 15.7), (18.0, 15.6), (19.0, 15.6), (20.0, 16.1), (21.0, 16.5), (22.0, 16.5), (23.0, 16.3), (24.0, 16.3), (25.0, 16.4), (26.0, 16.3), (27.0, 16.2), (28.0, 16.0), (29.0, 15.9), (30.0, 15.8), (31.0, 15.5), (32.0, 15.2), (33.0, 15.1), (34.0, 15.0), (35.0, 14.9), (36.0, 14.5), (37.0, 14.1), (38.0, 14.4), (39.0, 15.4), (40.0, 17.2), (41.0, 18.2), (42.0, 19.0), (43.0, 18.9), (44.0, 18.7), (45.0, 18.3), (46.0, 17.7), (47.0, 17.3), (48.0, 16.5), (49.0, 15.7), (50.0, 15.4), (51.0, 15.0), (52.0, 14.2), (53.0, 13.6), (54.0, 13.2), (55.0, 12.4), (56.0, 11.8), (57.0, 11.7), (58.0, 10.9), (59.0, 10.4), (60.0, 10.4)

Shareholder dividend sector
dividends = net_income_after_tax*dividend_policy
dividend_policy = .3

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