

An Intelligent System for Asset and Liability Assessment

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Abstract

In the volatile and competitive banking market *Asset and Liability Management* (ALM) is becoming increasingly mission critical. Swiss Bank has built an intelligent system, called BALET (BALance sheet Estimation Tool), which supports this ALM process by automating the assessment of financial indicators. To provide alternative options, BALET simulates the possible effects of various economic trends. BALET's principal user is a company's chief financial officer or corporate treasurer who's goal is to propose options that directly reduce the organisation's operational financial exposure, particularly when associated with interest rate risk and fluctuations. BALET's architecture consists of intelligent agents which defines these options (the simulation agent), analyse the alternatives (the analysis agent), generate hedges (the hedging agent), explore various interest assumptions and their implications (the interest rate agent), and generate intelligent reports (the report agent). These agents operate over an object-oriented business model of a company's balance sheet. BALET is in operational use at Swiss Bank and over 12 of their customers.

Introduction

Asset and Liability Management (ALM) is one of the core strategic tasks of a modern company. The formal definition of the process is as follows:

The optimal structuring of the balance sheet in terms of financial return, whilst at the same time controlling the risks caused by the fluctuations of financial markets on this structure.

Basically, the ALM manager needs to establish what the organisation is currently worth, and the risks that may threaten that value. The main risks of a balance sheet are as follows:

- **Interest Rate Risk** - Differences in an organisation's assets and liabilities result in exposure to interest rate fluctuations.
- **Currency Risk** - Changes in exchange rates can act to reduce organisational value.
- **Liquidity Risk** - To ensure liquidity, an organisation needs to maintain a predefined asset to liability ratio. This is of particular significance to Swiss banks where the required ratio is governed by law.

The most important and threatening risk is due to potential interest rate fluctuations. Correspondingly, the primary optimising objective is to control, or hedge, this factor by applying customised derivative instruments including swaps and options.

Swiss Bank has had great success in applying artificial intelligence technology to many of its operational activities, e.g., in credit evaluation [the CUBUS system presented at IAAI-91] and in mortgage lending [the MOCCA system presented at IAAI-92]. With this expertise and experience in hand, Swiss Bank undertook to develop an intelligent system (BALET) to support the more difficult ALM process. Prior to discussing BALET, we discuss the ALM process in more detail.

The Asset and Liability Management Process

The process of ALM should be viewed as a spiralling process with the discrete phases of *classification, analysis and optimisation*. At the conclusion of each optimisation phase, the ALM manager evaluates the forecasted risks and proposed hedging options, before determining whether or not to proceed with another loop of the spiral. The process completes when the ALM manager is content with the calculated level of risk and the structure of the balance sheet. The process has to be performed at regular intervals

to ensure an accurate risk assessment as external market values change over time.

Classification Phase. The initial phase is concerned with classifying the financial data of the company into meaningful groups which then act as the basis for the calculation phase. The main data source is the balance sheet which has to be supplemented with derived values for those items that are either incomplete or unknown. For example, the future cashflow implications of balance sheet items with variable interest rates need to be calculated by integrating assumed future interest values. Each balance sheet item is classified according to its specific interest rate and maturity.

There are 3 main categories or classes for these financial items:

- **Fixed interest rates and known maturity.** Financial items in this class have no ambiguity, and correspondingly no risk. They need no additional information in order to compute present values.
- **Variable interest rate.** Financial items in this class are modelled by projecting a replicating portfolio of capital slices, each with a given maturity. Each slice is then assigned historical interest rate according to its particular maturity.
- **No interest rate.** Some balance sheet items eg. equities, have both unknown interest rates and maturities. Therefore the values for these two items has to be assumed.

Analysis Phase. The analysis phase is aimed at calculating all of the financial measures that are used as standard indicators of the balance sheet status. These indicators include the Net Present Value (total value of the balance sheet), the Interest Rate Risk profile (an indication of the exposure to interest rate risk) and Gap Analysis (an asset to liability comparison). Once these financial indicators have been calculated, they are displayed in a form that feeds into the optimisation phase.

Optimisation Phase. The ALM manager determines whether he needs to hedge his current position. He is particularly concerned about his exposure to interest rate risk, and given high exposure, is able to defend his position by applying certain derivative instruments. These derivatives e.g., swaps or options, are complex financial tools that need to be specifically configured to suit the requirements of the current situation. The configuration includes the start and finish dates, the amount, the rate and the maturity profile. When all of the derivative instruments have been defined they are integrated with the findings of the previous analysis phase to check that they have reduced the level of exposure. This phase is then repeated, tuning the derivative instrument configuration, until the overall

position is considered by the ALM manager to be 'optimised'. In practice, this final optimisation may involve the ALM manager performing many iterations of this 'derivative tuning' before a satisfactory conclusion is reached.

This ALM process is complex. In order to perform each of its three phases well, a significant knowledge of financial assessment, risk analysis, and derivative tuning is required. This knowledge resides in ALM experts and thus represents an ideal domain for the application of artificial intelligence. In addition, as each phase of the process is calculation intensive, manual operation is both time consuming and often inaccurate. Developing an automated system that embodies ALM expert knowledge and automates the calculations represented a major opportunity at Swiss Bank. This intelligent system became known as BALET (BALANCE sheet Estimation Tool).

System Objectives

The main objectives of BALET were as follows:

- The complete ALM process should be automated by embedding and applying the knowledge required to calculate the required financial indicators.
- To support the user in the process of economic hypothetical reasoning. The tool should be equipped to integrate the results of its own calculations with the future economic assumptions of the user.
- To encapsulate the knowledge that is required to calculate hedging options.
- To operate within an environment of incomplete data. Where necessary, missing information is supplemented by data derived from a simulated economic model that is based on historical records.
- To optimise the derived economic position by proposing options to reduce the banks financial exposure. These options should include the definition of specific financial instruments, e.g., swaps, options, derivatives.
- To provide strategically powerful conclusions with relatively simple input. The tool should assume only limited user computing knowledge and should guide the user through the ALM process.
- The display of data should be flexible enough to allow the user to manipulate the display for views over different classes of balance sheet data.
- To generate user-modifiable reports.

BALET System Architecture

The architecture includes a collection of automated intelligent agents, where an agent is defined as a modular automated tool with a discrete operating task. We use the term *agent* because it suggests the analogy to human information workers, who are responsible for the production of information. As an analogy, consider the human workers in manufacturing, who instead of producing information, produce goods. Just as the production of goods has been largely automated by artificial agents (robots, machines), it is Swiss Bank's objective to automate financial information assessment, and to increase generally the level of automation in financial services. Thus, we consider the automated intelligent agents in the financial domain to be the 'information machines' of the information factory. We want these agents to be active, not just passive tools. From a production viewpoint they behave as human information entities, but operate in a more consistent and efficient manner.

The types of behaviour encapsulated within an agent is as follows:

- **Agent Triggers** Under what circumstances should this agent be initiated.

- **Data Requirements** The agent has a reference of all of the specific data that it requires to perform its task. If data is missing it is able to use its own mechanisms to assume data values. This is particularly used when forecasting forward interest rate curves, actual values are not available so BALET has to infer values based on its model of interest rate fluctuations.

- **Communication** Inter-agent communication is conducted via the global blackboard. Using this medium agents can post data that triggers other agents, or simply monitor the blackboard to await the command to execute.

- **Process Knowledge** - The detailed knowledge of how the specified task should be conducted. The hedging agent contains all of the knowledge that an expert financial practitioner would deploy to establish an optimal hedge.

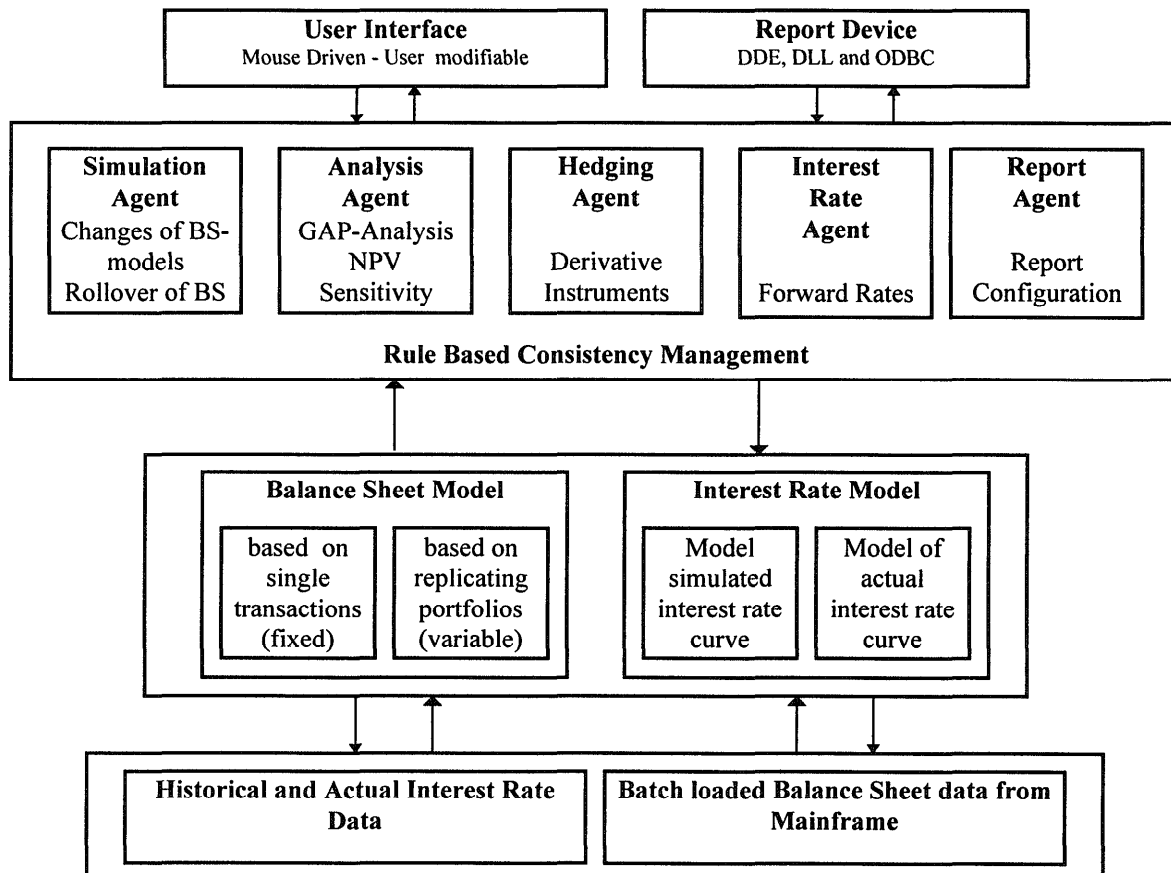


Figure 1. Balet System Architecture

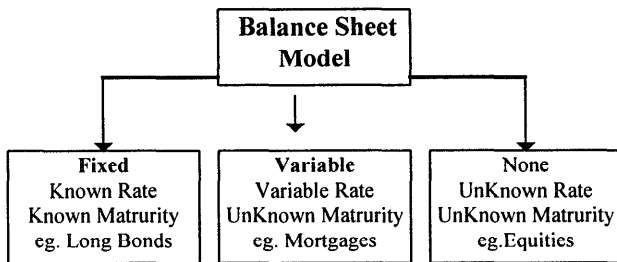


Figure 2 . Main Data Class Structure

This modularised agent approach has two main application maintenance benefits. First the autonomous nature of the agents with all of their embedded data requirements and behaviour localises the application debug process. Secondly the restricted inter-agent communication mechanism, via the blackboard, results in the uncomplicated deployment of agents as part of other agent-compliant applications. The interest rate forecasting agent could be re-deployed as part of an application that is designed to support the mortgage decision making process. The individual agents and their responsibilities include:

- **Analysis Agent** The core task of this agent is the calculation of the present values for each financial item in each balance sheet class. This includes Gap Analysis as well as the interest rate sensitivity. (See also Figure 3 and Figure 4.)
- **Hedging Agent** This agent helps in the definition and pricing of derivative instruments and integrates them into the balance sheet model. Its goal is to develop a 'perfect hedge' with the objective of no interest rate risk.
- **Interest Rate Agent** This agent provides, projects and calculates the different kinds of interest rates as they relate to par yield, zero coupon and forward rates.
- **Simulation Agent** The simulation component works together with the Interest Rate Agent. The simulation of an interest rate scenario is driven either by existing data or manually by a mouse.
- **Report Agent** Based on the actual session, BALET creates several different reports and writes them directly via a DDE channel into a Word document. Graphics are generated as postscript files. This kind of report generation guarantees highest flexibility in adding ones own comments to the standard reports produced.

In addition to defining and object-oriented agents, an object model of the balance sheet was developed to act as the framework for the simulation process. At the top level of abstraction the balance sheet item can be sub-divided into three main classes. (See Figure 2.)

The three main classes have much the same attribute structure but differ in their overall behaviour. Generally, calculations concerning fixed balance sheet items are

performed without reference to items defined outside the bounds of the object encapsulated data. In contrast, variable balance sheet items need their own data supplemented with data from a secondary source. Supplementary data may correspond to data from other related objects or it may relate to calculated data that is passed by one of the BALET agents. This secondary data requirement is illustrated by the calculation of a mortgage cashflow involving not only the locally defined values of loan size and monthly charge, but also the simulated data for the replicating portfolios provided by the interest rate agent.

Rule-Based Consistency Management

One of the key objectives of BALET was to enable the user to experiment with potential financial scenarios. The system had to perform hypothetical reasoning. As part of this process a mechanism for maintaining the integrity of the blackboard was devised using ART**Enterprise* rules. Correspondingly, as the user decides to backtrack to an earlier assumption, so to BALET retracts all of the data and inferences that were generated after that assumption. This is what the BALET team refer to as rule-based consistency management.

System Operation

The operation of BALET was specifically modelled to follow the existing manual ALM processing phases of *classification, analysis* and *optimisation*.

Classification Phase. The initial task of BALET is to load the balance sheet and classify the financial data. Each item on the balance sheet is assigned to one of the classes that will dictate how the item is calculated and applied as part of the ALM process.

Analysis Phase This phase is aimed at calculating and displaying the various financial indicators that were required for the ALM process. As discussed earlier, the Net Present Value (NPV), Interest Rate Profile (exposure to risk), and GAP analysis (asset to liability comparison) are standard ALM measures.

The main GAP analysis window (Figure 3) represents time along the x-axis and assets (Akt) and liabilities (Pas) along the y-axis. Using a monthly base, BALET calculates all future cashflows and displays the maturity model of the balance sheet. A gap is defined as the situation where the amount due within a certain period on the asset side differs from the amount due on the liability side in the same period. The gaps of all time periods together provide the gap analysis.

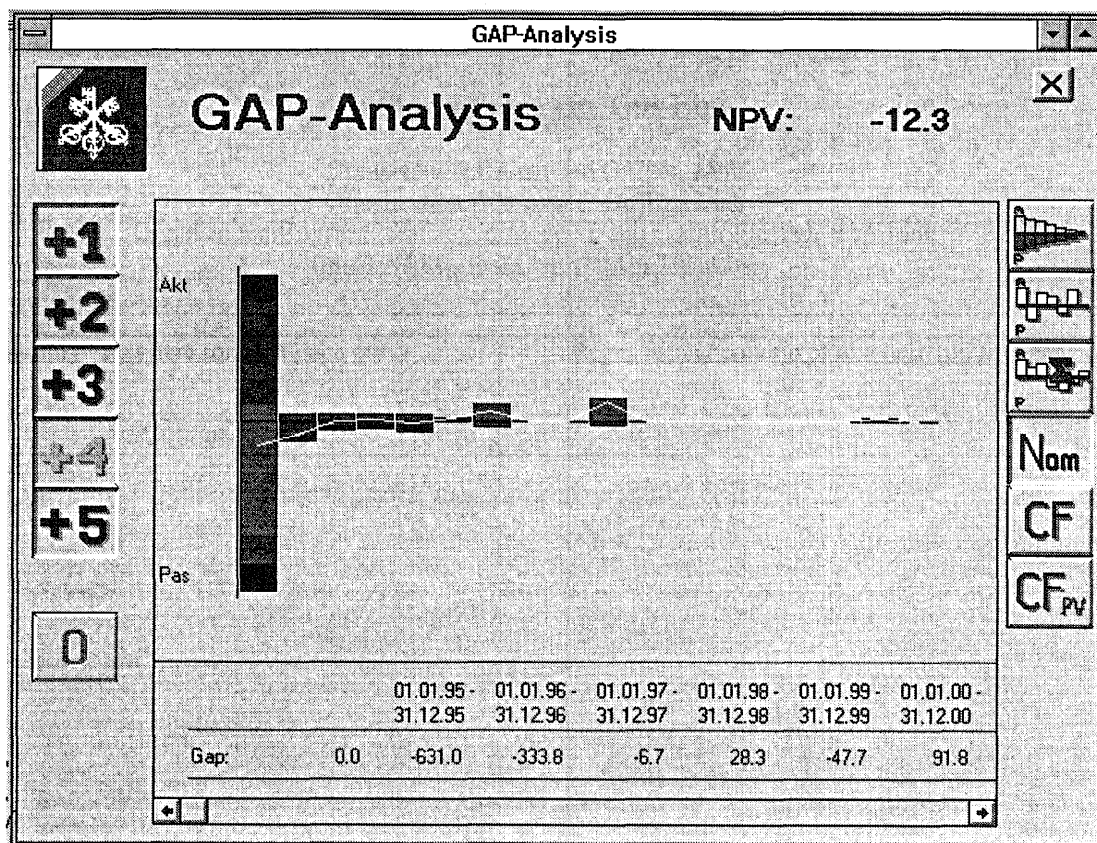


Figure 3. BALET GAP Analysis

The light-coloured single line on Figure 3 illustrates that the gap is initially negative, but moves towards the positive in the long term. The buttons on the left and right of the main GAP analysis display offer the user alternative views over the financial data. The numbers on the left control the display of items from specific classes. This enables the user to view the effect of GAP analysis on a subset of the balance sheet. The buttons on the right control the content of the data displayed, switching between the display of GAP, cash flow, and cumulative GAP. At the top of the window the balance sheet Net Present Value (NPV) is displayed. The exposure to interest rate risk is displayed in the Interest Rate Profile window. The example display in Figure 4 illustrates how the current balance sheet is exposed to interest rate fluctuations. If the interest rate were to increase 1% (100 basis points) the losses would be over **44 million** on the current position. If the interest rate remained constant then the loss/profit would be nil. A reduction in interest rate of 1% would improve the current position by **66 million**. The goal of the optimisation phase is to flatten the risk profile by deriving and applying hedging instruments.

The simulation of key economic factors can either be inferred by BALET's simulation agent or modified by the user. The user is able to define custom interest rate curves by hand using the mouse or by typing a list of numbers. Once these values have been entered, BALET recalculates the economic indicators that will have been affected by the changing forward interest rate assumption.

Optimisation Phase. The reduction of the interest risk exposure can be performed by creating derivative instruments and asserting them to the system. BALET's hedging agent generates an optimal hedge with swaps and integrates these with the existing balance sheet. After these swaps have been recalculated with the rest of the balance sheet the resultant exposure profile is illustrated by the light coloured line in Figure 4.

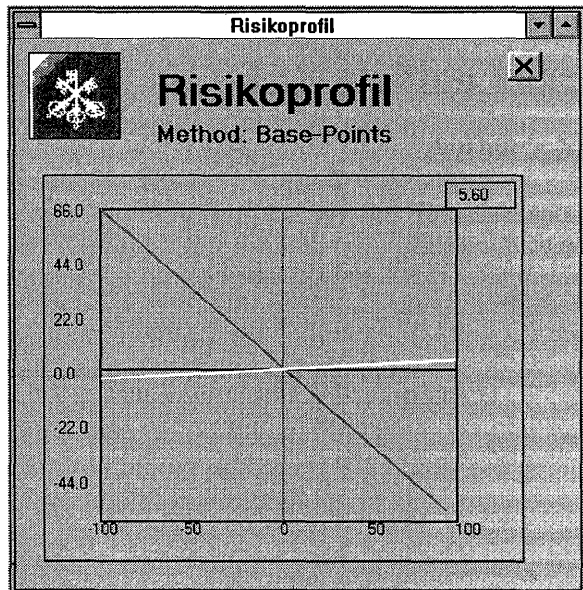


Figure 4. Interest Risk Profile

Note that the line runs from left to right horizontally almost along the zero exposure line. This flattening of the exposure line represents a balance sheet that has been optimally hedged. Fluctuations in the interest rate would have only a minimal effect on the net value of the balance sheet.

Application Payoff

The application is considered to be successfully deployed for the following reasons:

- **Early Return On Investment** The application has been so successfully received by Swiss Banks customers that they have been prepared to purchase licenses of the product. The revenues generated by these sales have already returned all of the initial development costs.
- **Corporate Financial Risk Reduction** BALET performs a significant role in the reduction of an organisation's exposure to interest rate risk. Depending on the size of the organisation, these losses can run into millions of dollars. The hedges that BALET proposes attempt to reduce the interest rate risk close to zero.
- **Improved Customer Service** The tool has supported the bank's front office process, advising its corporate clients on issues relating to ALM and risk management. The bank's customer relationship officers are able to present the findings of BALET on a portable computer at the customer's office. This innovative approach has improved, still further, the professional level of service that Swiss Bank delivers to its customers.

Platform and Resources

BALET is deployed on a Pentium PC with 32Mb of RAM. The tool was developed using the ART*Enterprise development environment. The development lifecycle including beta testing and final production testing took 6 elapsed months involving approximately 10 man months of effort. From the user community the total manpower utilisation was less than two months to define the simulation models and test the working system.

Maintenance

BALET is strongly modularised (due to the agent-model architecture). The single agents are developed and updated independently and can be regarded as an enhancement of BALET's core. Correspondingly, the development of new more advanced agents, particularly within the hedging module, can be easily integrated into the core application. Updates in market data can be loaded by the user and are regularly provided by Swiss Bank on floppy disks. Delivery using the Internet is currently being considered.

Use

BALET has now been in operational use since February 1995 and new versions are being developed to integrate the additional features demanded by the current user base. BALET is operational and in use at Swiss Bank and over 12 of its customers. This number is steadily increasing as the tool is demonstrated to the banks customers.

Summary

BALET's automation of the Asset and Liability Management process has been enthusiastically received by both internal Swiss Bank users and customers alike. Its success is based on its ease-of-use, and on its automation of a task that is both complex and knowledge dependent. The conclusions are quickly delivered enabling the ALM manager to rapidly explore possible options while performing the difficult process of balance sheet optimisation.

References

Wenger, D. 1995 Financial Information Engineering. The Development of AI Agents. Ph. D. diss., University of Lausanne, Switzerland.

Inquiries

If you have any questions about the operation or availability of the BALET product then please contact.

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