ALM in Banking

Jean Dermine
INSEAD, F-77300 Fontainebleau, France
jean.dermine@insead.edu

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Abstract

The main purpose of the chapter is to discuss Asset & Liability Management, the control of value creation and risks in a bank. This chapter is innovative in two ways. First, unlike the usual practice of restricting ALM to the control of interest rate and liquidity risks, we propose a framework to analyze both value creation and the control of risks. Second, rather than discuss the ALM issues one by one in an independent manner, the chapter provides a microeconomic-based valuation model of a bank. This allows an integrated discussion of fund transfer pricing, deposit pricing (fixed and undefined maturities), loan pricing, the evaluation of credit risk provisions, the measurement of interest rate risk for fixed and undefined maturities, the diversification of risks, and the allocation of economic capital.

Besides a comprehensive summary of the literature on ALM in Banking, the chapter makes six contributions related to transfer pricing, risk-adjusted pricing of loans, provisioning of credit risk, the relevant maturity to price and hedge deposits with uncertain maturities, the after-tax valuation of equity, and the hedging of economic profit.

ALM in Banking

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Introduction

The main purpose of this chapter is to discuss Asset & Liability Management, the control of value creation and risks in a bank. The chapter aims to be comprehensive with a large coverage of the ALM literature, and to be innovative in two ways. First, unlike the usual practice of restricting ALM to the control of interest rate and liquidity risks arising from positions on balance sheet (the banking book),[1] we propose a framework to analyze both value creation and the control of risks. Second, rather than discuss the ALM issues one by one in an independent manner, we provide a microeconomic-based valuation model of a bank. It allows us to discuss, in an integrated way, fund transfer pricing, deposit pricing (fixed and undefined maturities), loan pricing, the evaluation of credit risk provisions, the measurement of interest rate risk for fixed and undefined maturities, the diversification of risks, the marginal risk contribution, and the allocation of economic capital. The traditional purpose of ALM, the control of interest rate and liquidity risks, is thus integrated into a richer framework.

With reference to the organizational structure of banks, our integrative approach is closer to the organization of a J.P. Morgan Chase which operates with two major corporate risk committees : Capital and Risk Management. The Capital Committee reviews the adequacy of the firm's capital and liquidity, and recommends the allocation of capital within the firm. The Risk Management Committee provides oversight and direction of risk profile and risk appetite, and reviews and approve corporate policies and risk strategies in a comprehensive way, not restricted to liquidity or interest rate risk on the banking book.

In Section 1, five specific but interrelated functions of banks are discussed in the light of modern banking theory. This permits us to identify the various services provided by banks. The balance sheet and income statement of a representative bank are presented in Section 2. As bank modelling is often concerned with the management of risks, fifteen sources of risk in banking are identified in Section 3, and the economics of risk management are discussed. Two microeconomic models of the banking firm are developed in Section 4. A neoclassical model facilitates discussion of the bank separation theorem and the pricing of deposits with fixed and undefined maturities. A bank valuation model enables us to break the value of the equity of a bank into four components: a liquidation value, a franchise value, a corporate tax penalty, and tax savings due to unrealized capital gains. Specific attention is given to relevant risk-adjusted discount rates to value bank assets and liabilities. Three applications of the model follows. In Section 5, the valuation model is applied to the pricing of risky loans and the fair evaluation of

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[1]For instance, Crouhy *et al.* (2001) and Bessis (2002).

credit risk provisions. The discussion of the measurement of interest rate and liquidity risks in Section 6 will concern the risk on the banking book from both an 'accounting earnings' and an 'economic value' perspectives. Both finite maturity-products, such as term loans or term deposits, or products with undefined maturities, such as demand deposits or credit card loans, will be analyzed. We discuss, in Section 7, the aggregation of risks, the concept of marginal risk contribution, and the allocation of economic capital. Finally, in Section 8, we review briefly the rationale for bank regulation and the main types of regulations, as they relate to capital adequacy, interest rate risk, and liquidity risk.

Besides a comprehensive summary of the literature on *ALM in Banking*, this chapter makes six contributions related to transfer pricing, risk-adjusted pricing of loans, provisioning of credit risk, the relevant maturity to price and hedge deposits with uncertain maturities, the after-tax valuation of equity, and the hedging of economic profit.

Section 1: Economics of Banking, Five Main Functions

A bank is a firm whose assets include primarily financial claims issued by borrowers, such as households, corporate firms, governments, and other financial intermediaries, and whose liabilities are sold as secondary claims to capital surplus units in various forms, such as demand deposits, savings deposits, term deposits, subordinated debt (loan capital), or equity shares. Keeping up with financial innovations, banks engage in various credit insurance-related activities, such as letters of credit, note-issuance facilities, or credit derivatives. Others types of contingent claims include financial derivatives, such as forwards, options or swaps, the payoffs of which are related to movements in interest rate, exchange rates, equity or commodity prices. With the exception of the transaction cost and the cash premium received or paid, these activities do not create an asset or a liability on the balance sheet. They belong to the *off-balance sheet* activities. Although the services provided by banks are interrelated, it is convenient to distinguish five categories of increasing complexity : underwriting and placement, portfolio management, payment (transmission) services, monitoring or information-related services, and risk sharing.

Underwriting and placement: A first service provided by financial intermediaries is to bring together savers and borrowers. Underwriting and placement of securities is a function which helps borrowers (corporate firms or public institutions) to meet surplus units, and structure or customize the type of securities that meet the risk/return requirements of borrowers and lenders. In this function, the underwriter is involved not only in designing the security, but also in the valuation of assets and the pricing of securities to ensure that the terms of the issue are competitive. Increasingly, rating agencies play a crucial role in providing independent evaluation of the risks incurred on these claims. As investors may wish in the future to transform these claims into cash, consumption or other securities, they need to be exchanged. Brokers/dealers or market makers provide these services to ensure secondary trading and liquidity. In a pure underwriting and placement service, it is assumed that the return and risk of the securities can be properly defined, so that there is no major problem of asymmetric information (agency problem) between lenders and borrowers. In this case, monitoring is not an issue. A pure case is the financing of public debt in countries where the sovereign risk is minimal. With the underwriting and placement service, the end-investor holds directly the claims on deficit units.

Portfolio management: At low cost, investors can acquire a diversified portfolio of securities issued by deficit spending units. The pure case is the mutual fund or unit trust (called SICAV in France and Luxembourg) which supplies a diversified portfolio to the holders of its shares. The income derived from the financial assets is paid to the holders of the shares less a fee paid to the fund manager.[2] The reason for the existence of these funds is twofold. The first is to reduce the divisional cost incurred in issuing many securities. The second is that investors may wish to delegate the assessment of economic prospects and fund management to specialists.

Payment mechanism: a third function performed by financial markets is the management of the payment system, i.e. to facilitate and keep track of transfers of wealth among individuals. This is the bookkeeping activity of banks realized by debiting and crediting accounts. Although the payment system is limited by regulation to a specific type of deposits (demand deposits), it could be achieved by debiting or crediting any type of liquid assets. The so-called cash management or sweep account which automatically transfers money from mutual funds into demand deposits is a perfect illustration of the possibility of extending the payment system to other assets.

Monitoring and information-related services: Private information held by borrowers leads to contracting problems, because it is costly to assess the solvency of a borrower or to monitor his/her actions after lending has taken place (Stigliz and Weiss, 1981). Sometimes, it is useful to package these claims in a portfolio, and banks perform a useful function in reducing the costs of screening and monitoring borrowers. The delegation of screening and monitoring to banks has been shown to be an efficient mechanism.[3] This fourth service is linked to the first one, underwriting and placement. It is taken here as a separate service as it corresponds to those cases where significant information asymmetries make it difficult to issue financial claims traded on securities markets. While the second service, portfolio management, refers to the management of liquid assets, this fourth function refers to the management of the credit portfolio, most often the far larger part of a bank's balance sheet.

Risk-sharing service: An increasingly important function of banks is to make the market more complete, i.e. to provide tools to transfer money (consumption) across states of the world. Several examples will be illustrated. First, banks not only supply diversified assets, but also organize efficiently the distribution of risky income earned on the asset pool. The debt holders

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[2]See Black (1970), Fama (1980), and Dermine, Neven and Thisse (1991) for a portfolio view of financial firms.

[3]Diamond (1984) and Fama (1985).

receive a fixed payment while the shareholders receive the residual income. Other insurance services include interest rate insurance (floating rate lending with various ceilings on interest rates called caps or floors), inflation insurance with real contract, and liquidity insurance, option for deposit holder or the holder of a line of credit to withdraw quickly at face value (Diamond and Dybvig, 1983 ; Rajan, 1998). Allen and Santomero (1998, 2001) have emphasized the growing importance of risk management services provided by commercial banks.

Generic economic functions of banks have been presented. The Second Banking directive[4] of the European Commission lists the specific activities that can be authorized by central banks in the European Union:

• Deposit-taking and other forms of borrowing
•Lending
• Financial leasing
• Money transmission services
•Issuing and administering means of payments (credit cards, travellers'cheques and bankers'drafts)
•Guarantees and commitments
• Trading for own accounts or the account of customers in
     Money market instruments
     Foreign exchange
     Financial futures and options
     Exchange and interest rate instruments
     Securities
•Participation in share issues and the provision of services related to such issues.
•Money broking
•Portfolio management and advice
•Safekeeping of securities
•Credit reference service
•Safe custody service

This complete list describes the activities of a *universal bank*. In some countries, such as the United States or Japan, the list of permissible activities was greatly reduced (Saunders and Walter, 1994). But there has recently been a regulatory convergence towards the *universal*

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[4]Directive 89/646/EEC.

banking model. For instance, the Financial Modernization Act (Gramm-Leach-Bliley) of 1999 in the United States has repealed the Glass-Steagall Act which separated commercial banking and securities underwriting. The banking systems of most countries of Latin America and Central and Eastern Europe were deregulated with the adoption of the universal banking model.

Section 2: The Bank's Balance Sheet and Income Statement

Before discussing modelling, it is useful to present the balance sheet and income statement of a representative bank. The consolidated balance sheet presented below is that of the Royal Bank of Canada for the year ended October 31, 2000.

Assets (Can$ million)		Liabilities and Shareholders' Equity (Can$ million)	
Cash resources		**Deposits**	
Cash and due from banks	947	Canada	
Interest-bearing deposits with other banks	18,659	Non-interest bearing	22,011
	19,606	Interest bearing	116,113
		International	
		Non-interest bearing	863
		Interest bearing	67,250
Securities		**Other**	
Trading account	46,366	Acceptances	11,628
Available for sale	13,199	Obligations related to	
Held to maturity	698	securities sold short	12,873
	60,263	Obligations related to assets sold under	
		repurchase agreements	9,005
		Derivative-related amounts	18,574
		Other liabilities	15,912
			67,992
Assets purchased under repurchase agreements	18,303	**Subordinated debentures**	5,825
Loans		**Non-controlling interest in subsidiaries**	703
Residential mortgage	62,984		
Personal	28,019		
Credit card	4,666		
Business and govern. loans and acceptances			
	72,143		
	187,812		
Allowance for loan losses	(1,871)		
	165,941		
Other		**Shareholders' equity**	
Derivative-related amount	19,334	Capital stock	
Premises and equipment	1,216	Preferred	2,001
Goodwill	693	Common	3,074
Other intangibles	208	Retained earnings	8,314
Other assets	8,490	Accumulated other comprehensive income	(92)
	29,941		13,297
Total assets	294,054	**Total liabilities and shareholders' equity**	294,054

Table One: Consolidated Balance Sheet

Source : Royal Bank of Canada, 2000 Annual Report

The consolidated Income Statement of the Royal Bank of Canada for the year ended October 31, 2000 follows:

Interest income (Can$ million)	
Loans	11,538
Trading account securities	1,435
Available for sale and held to maturity securities	1,083
Assets purchased under reverse repurchase agreements	1,078
Deposits with banks	975
	16,109
Interest expense	
Deposits	9,057
Other liabilities	1,429
Subordinated debentures	344
	10,830
Net interest income	5,279
Provisions for credit losses	691
Net interest income after provisions for credit losses	4,588
Non-interest revenue	
Capital market fees	1,810
Trading revenues	1,540
Deposit and payment service charges	756
Investment management and custodial fees	684
Mutual funds revenues	528
Credit card revenues	420
Securitization revenues	104
Gain (loss) on sale of securities	(11)
Other	849
	6,680
Non-interest expenses	
Human resources	4,695
Occupancy	570
Equipment	664
Communications	695
Other	1,004
	7,628
Net income before income taxes	3,640
Income taxes	1,412
Net income before non-controlling interest	2,208
Non-controlling interest in net income of subsidiaries	20
Net income	2,208
Preferred share dividends	(134)
Net income available to common shareholders	2,074

Table Two: Consolidated Income Statement

Source : Royal Bank of Canada, 2000 Annual Report

With respect to the five functions of banks discussed earlier, one can observe that non-interest revenues, originating from trading of securities, management of the payment system, or fund management, exceeds net interest income, respectively, Can\$ 6,680 million and Can\$ 5,279 million. Over the years, banks have diversified their sources of revenue, and the share of fee-based services has increased.

To model the bank, we will very much simplify the balance sheet and income statement. The balance sheet of a bank used for modelling purpose is as follows:

Assets	**Liabilities and Shareholders' Equity**
Reserves with Central Banks	Retail Deposits
Retail Loans	Demand deposits
	Savings deposits
	Term deposits
Corporate Loans	Corporate Deposits
	Demand deposits
	Term deposits
Interbank Loans	Interbank Deposits
Government Bonds	Subordinated Debt
Fixed assets	Equity

A bank's simplified balance sheet

Banks collect deposits on the retail and corporate markets. Some of these are withdrawable on demand (demand deposits used for the payment system). Others, such as savings deposits, can be transferred into other deposit accounts on demand. The maturities of these first two types of deposits are said to be 'undefined', as deposits could stay in the bank for a few days or a few years. The undefined maturity creates a specific problem to price these deposits, and to measure their interest rate and liquidity risks. These issues will be addressed in Sections 4 and 6. Others deposits, the term deposits, have a fixed contractual maturity. Finally, the pricing could be a 'fixed rate', or a 'floating rate' linked to a short-term benchmark rate, such as the interest rate on government treasury bills or the interbank rate. Besides money raised form the public, banks borrow from one another on the interbank market with interbank deposits. Finally, two sources of long-term funds include subordinated bonds and equity. Subordinated debt plays a special role in banks as they qualify, along with equity and upon some eligibility limits, for the definition of regulatory capital.

On the asset side, banks must hold some reserves at the central bank, reserves which pay a low

(often zero) interest rate. As discussed in Section 1, a main function of banks is to lend money to individuals or corporations. Excess funds can be lent to other banks (interbank loans) or used to purchase government bonds. Finally, a small proportion of funds is used to purchase fixed assets, such as buildings and computers. The mismatch between the maturities of assets and liabilities can create interest rate and liquidity risks. This is discussed in Section 6.

In addition to balance sheet items, banks are involved into a large set of off-balance sheet activities, such as derivatives (forward rate agreements, options or swaps) or loan commitments and guarantees. They are called off- balance sheet or contingent claims, as, except for incurring a small transaction cost or a premium, they have no impact on the balance sheet at origination. They will create a cash flow (positive or negative) when some contingency occurs.

The simplified income statement used for modelling purpose is as follows :

Interest income
- Interest expense
+ Fee/trading income
Gross income
- Loan provisions
- Operating expense
Earning before tax
- Tax
Earnings after tax

A bank's simplified Income Statement

Interest income is earned on loans and bonds, while fee/trading income is generated by various services or trading. Interest expenses include the cost of deposits and subordinated debt. A very specific and difficult issue in banking concerns the creation of loan provisions to take into account the loss of value of loans. As loans are usually not traded on capital markets, there is no information readily available on what is the fair value of a loan. Moreover if the borrower goes into difficulties and bankruptcy proceedings, it may take several years to know the exact amount of loan losses. As a consequence, a method must be devised to set the *fair* level of provisions for credit risk. This is discussed in Section 5.

Section 3:   Risk Management in Banking

An identification of the sources of risk in banking is followed by a discussion of the economics of corporate risk management.

3.1 Risks in Banking

At least fifteen sources of risk can be identified in banking. They can be grouped into four major categories: credit, market, liquidity, and operational risks. A comprehensive, and possibly joint, management of these sources of risks is referred to as ERM, Enterprise-wide Risk Management (Rosen and Zenios, this volume).

- •Credit Risk
  - •Retail and Corporate Credit Risk
  - •Counterparty Risk
  - •Settlement Risk
  - •Environmental Risk
  - •Country Risk

- •Market Risk
  - •Interest Rate Risk
  - •Foreign Exchange Risk
  - •Equities
  - •Commodities

- •Liquidity Risk

- •Operational Risk
  - •Execution Risk
  - •Model Risk
  - •Fraud
  - •Legal Risk
  - •Regulatory Risk

Credit risk refers to the non-payment on time by a retail, corporate, or institutional borrower of interest and/or principal. **Counterparty risk** refers to a particular type of credit risk, in which

the borrower is a financial institution. **Settlement risk** (sometimes referred to as *Herstatt* risk)[5] is a particular type of counterparty risk. It refers to the risk involved in selling securities or foreign exchange. A time difference in settlement dates could imply that one party has already delivered the security before the payment is completed. **Environmental risk** is a type of credit risk in which the guarantee on a loan contract may force the bank to hold real assets with some environmental liability. **Country risk** refers to the potential losses that could arise when a country, facing a severe economic crisis, takes actions that are detrimental to the bank (such as nationalization, increases in taxes, or capital controls).[6]

Market risk refers to the loss of revenue due to adverse movement in interest rate, foreign exchange, and prices of securities or commodities. With specific regard to interest rate risk, one makes a distinction between the banking book and the trading book. Due to accounting rules, the banking book is accounted for on an accrual basis (i.e. assets and deposits are recorded at acquisition cost). The banking book generates a net interest income (net interest margin) in the profit & loss account (P&L). A first source of interest rate risk concerns therefore the volatility of the net interest income. The trading book is marked-to-market, either at actual market prices when these are available, or at calculated *fair* present values. The change in value of the trading book is recorded in the P&L. A second source of interest rate risk is the impact of interest rate on the value of the trading book.

Liquidity risk refers to the shortage of cash originating from a loss of bank deposits, unexpected draw downs on loan commitments, or margin calls on trading transactions.

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[5]The medium-sized German Bankhaus Herstatt defaulted on 26 June 1974 at the end of the business day. Some of the bank's counterparties had irrevocably paid Deutschemarks to the bank before the bank's license was withdrawn. These counterparties were expecting to receive US dollars in New York that same day. However, the termination of the bank took place at 10:30 am in New York, prompting Herstatt's correspondents to suspend all outgoing US dollar payments. It left U.S. counterparties with losses exceeding $600 million.

[6]An example of country risk is that of Argentina on January 6, 2002 when the Parliament approved the end of the currency-board system (a one-to-one parity between the peso and the US dollar). A key-measure of the plan was to convert the banks' dollar loans into pesos at a one-to-one exchange rate, while deposits were converted at 1.4 pesos to the dollar. This created a large and unexpected currency mismatch between assets and liabilities, which increased even further in 2003. As the peso plunged to 3.18 pesos to the dollar, 180,000 depositors filed lawsuits againt the decree. On March 5th, the Supreme Court ruled that the conversion of deposits to pesos was illegal, allowing depositors to claim dollars (The Economist, March 8th 2003).

Operational risk, in its widest definition, includes every risk other than credit, market and liquidity risks. It is the risk of loss resulting from inadequate or failed internal processes, people and systems or external events. More specifically, **execution risk** refers to losses due to data entry errors[7] or computer failures. **Model risk** refers to losses incurred when the mathematical modelling of financial instruments does not match movements in actual market prices. **Fraud** refers to outright stealing of value by employees or clients. **Legal risk** involves unexpected losses due to legal liabilities. **Regulatory risk** refers to the losses arising from an unexpected change in regulations, such as more stringent capital requirements.

Sometimes, a specific loss (such as trading or credit losses) can generate a much larger fall in the market value of the shares of a bank than the loss itself. This is often explained by a loss of confidence in the management of a bank. The "blowing up" of an initial loss, arising from credit, market, liquidity or operational risks, is referred to as **reputational risk**. It is particularly acute in banking because of the *opacity* of bank operations. Given the very large number of transactions, sometimes in many countries, and the holding of non-tradable instruments, it is very difficult for an outsider to verify the quality of the management of a bank. A loss can therefore be a signal of bad quality, which explains the amplified fall in market value.

3.2 The Economics of Risk Management

In a world with perfect information and complete markets, corporate firms, for instance banks, should not allocate resources to risk management. Perfectly informed shareholders could manage themselves an optimal reduction of risks. Four motivations for corporate risk management have been advanced in the literature (e.g., Santomero, 1995 ; or Froot and Stein, 1998): managerial self-interest, non-linearity of taxes, cost of financial distress, and capital market imperfections. These are discussed briefly.

First, managerial self-interest refers to the fact that managers, having a significant fraction of their permanent income attached to the firm, cannot diversify risks adequately. Managers' risk aversion will lead to risk mitigation. Second, the non-linearity of taxes means that losses may not be fully tax-deductible, or that large profits could be taxed at a higher rate. In this case, a reduction of profit variance leads to a reduction of expected tax payments. Third, the cost of financial distress refers to the loss of value due to a state of distress. In banking, this could imply

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[7]On May 14, 2001, a trader of an investment bank in London keyed in the wrong number of shares on his/her trading screen. The mistake meant that a sell order on a basket of shares worth a reported US$ 30m turned into one valued ten times that. The FTSE 100 Index fell by 2.2 % when the trade was made (The Economist, May 19, 2001).

a loss of clientele or a loss of a profitable banking license (the 'charter value'). Fourth, costs may arise from capital market imperfections. Because of asymmetric information, banks may find it costly to raise external funds. In such a context, losses could lead to a lower equity level, and profitable investment opportunities which are missed. Stabilization of profit can reduce the call for expensive external finance, and lead to the realization of profitable investments. An alternative explanation of the resources spent on risk control is linked to reputational risk. Because of opacity, investors cannot evaluate whether a reported loss is due to bad luck or to inferior management quality. In this context, stabilization of profit prevents a loss of value. So, even in the absence of bank regulation, there are several economic motivations for the control of risks in a bank.

Section 4: Asset and Liability Modelling for Banks

The modelling approach presented below is rooted in the microeconomics of banking and in finance theory. A neoclassical economic model of the banking firm is followed by a valuation-based model.

4.1 A neoclassical model of the banking firm and the separation theorem

The simplest model is the neoclassical model of the banking firm developed by Klein (1971) and Monti (1972).[8] The asset side of the balance sheet of the bank consists of reserves with the central bank (R), loans (L), and market-traded assets such as government bonds (B) or interbank loans. The liability side includes deposits (D) and equity (E). The regulatory reserves, yielding no interest, are a fraction *r* of deposits. The supply of government bonds (yielding an interest rate *b*) is perfectly elastic in competitive markets. The balance sheet is as follows:

Asset	Liabilities and Shareholders'Equity
Reserves	
Loan	Deposits
Bonds	Equity

The loan demand by borrowers (L(.)) is a decreasing function of the interest rate *p* and the deposit supply (D(.)) is an increasing function of the interest rate *d*. All these assets and deposits have the same maturity, say one year and, at this stage, all parameters are known with certainty. Operating expenses linked to deposits and loans are left out for simplicity.

The opportunity cost of equity in this certain world is the exogenous government bond rate *b*. The bank chooses deposit and credit rates to maximize its end-of-period economic profit (EP), that is the accounting profit reduced by an opportunity cost of equity:

$$\text{Max} \quad EP = (pxL + bxB - dxD) - bxE \tag{1}$$
$$\text{subject to } R + L + B = D + E .$$

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[8]See extension of the neoclassical model in Baltensperger (1982), Santomero (1984), Dermine (1984, 1986), and Freixas and Rochet (1997).

Substituting the balance sheet constraint into the objective function, one has:

$$\text{Max EP} = [(p-b) \times L] + [(b \times (1-r) - d) \times D].\tag{2}$$

The economic profit is the sum of two terms: income on loans net of an opportunity cost (the government bond rate b), and income on deposits invested in securities with a return reduced by the central bank's reserve requirement. For each Euro raised, only $(1-r) \times$ Euro is available for investment. This simple relation has given rise to the important *separation theorem* in banking, which suggests pricing loans and deposits independently, with reference to the market rate (government bonds or interbank rate). The first order condition for deposit and credit rates are :

$$\partial EP/\partial d = (b \times (1-r) - d) \times D' - D = 0\tag{3}$$
$$\partial EP/\partial p = (p - b) \times L' + L = 0.\tag{4}$$

Denoting by η_D and η_L the interest rate elasticity of deposits and loans, one obtains:

$$d = b \times (1 - r) \times (1 + \eta_D^{-1})^{-1}, \quad p = b \times (1 + \eta_L^{-1})^{-1}.\tag{5}$$

This can be represented in the following graph, the reserve requirement being set at zero, for the sake of exposition:
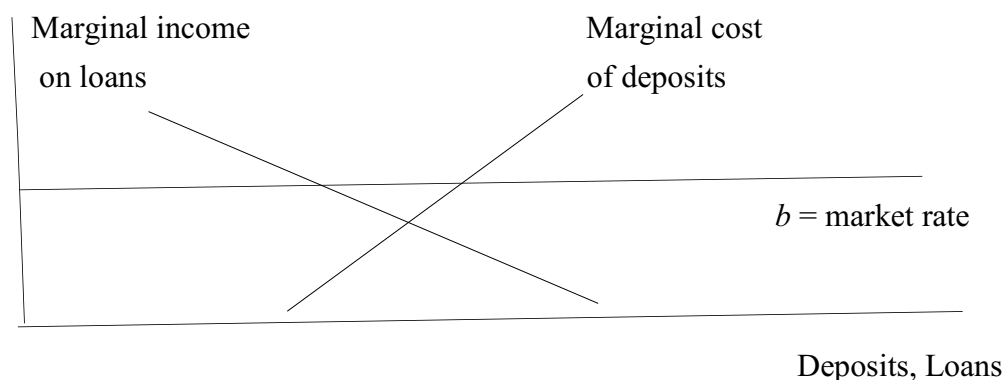

Figure One : The Separation Theorem

The horizontal line represents the perfectly elastic market rate b. The other two lines represent the marginal income on loan and the marginal cost of deposits.. The graph illustrates that the optimal volume of deposits is reached when the marginal cost of deposits is equal to the opportunity market rate. Similarly, the optimal volume of loans is reached when the marginal

revenue from loans is equal to the marginal investment return, the market rate b. One notices the separation between the lending and funding decisions. Knowledge of the market rate, the reserve requirement and the price elasticities allows one to choose the optimal interest rates on deposits and loans. The difference between the optimal volumes of deposits and loans is the net position in market assets. In the graph, it is positive with the bank being a net lender in the market. But it could be negative with the bank being a net borrower.

The bank's separation theorem is useful in practice for two reasons. First, it allows us to identify the relevant interest rate to price deposits or loans. Second, it permits the division of the bank into a set of profit centers. Indeed the economic profit in equation (2) is shown to be the sum of two terms : the profit (net interest margin) on loans and the profit on deposits. One can therefore break up the bank into different sources of economic profit, or into different value centers, the transfer price needed to evaluate the profit on deposits or loans being identified as the market rate with the same maturity as the product. This rate is known as the MMMVF, the matched-maturity marginal value of funds. The expression 'breaking up the bank' was used to refer to the fact that the deposit-taking and lending activities could be, each, evaluated on its own.

Given the wide application of the MMMVF in banking, a natural question arises as to which economic factors would break the bank separation theorem To break the theorem, one simply needs to introduce a joint cost or revenue function in deposits and loans. A joint revenue function could exist if the volume of deposits received is linked to the volume of loans granted. For instance, the terms of mortgage loans could impose the opening of deposit accounts with the same bank. The joint cost function could have two origins: there could be joint operating expenses in delivering deposits and loans, and, if there is a cost due to a liquidity crisis, it will be linked to the joint amount of deposits and illiquid loans. Indeed, *ceteris paribus*, if there is a large volume of loans, there will be a low volume of liquid government bonds that can be sold to meet deposits withdrawals. One must realize that *joint maximization* of economic profit on loans and deposits will be the rule in the case of a joint cost or revenue function. The simplicity of the separation theorem disappears in this case. Joint maximization is particularly relevant for banking systems experiencing significant liquidity risks. Cases are to be found not only in emerging countries, but also in countries in which the deposit base of banks has been eroded by competing financial products, such as money market funds, mutual funds, or pension funds. An additional argument for joint maximization, risk diversification, will be discussed in Section 7.

5.2 A multi-period neoclassical model of the banking firm

In the one-period model, the relevant transfer price for pricing and for the evaluation of profitability is the matched-maturity market rate. A six-month interbank rate is the relevant rate to price a six-month deposit. However, two additional features can introduce a multi-period consideration (Dermine, 1984 ; Hannan and Berger, 1991). The first is that the supply of deposits can be a lagged function of past deposit rates. This is likely to be the case in the retail sector in which customers, facing switching costs, will display some form of loyalty. This creates a lag in the deposit supply function. The second reason for dynamic consideration is that, for marketing reasons, it can be costly to continuously adjust the deposit rate. One speaks of deposit rate rigidity, or "stickiness".[9]

Let us consider a two-period model with b_1 the bond rate in Year 1, and b_2 the forward rate in Year 2.

Let us first consider the lagged supply case , i.e.

$$D_2 = D_2 \, (d_2, d_1).$$

In this case, the maximization of profit on deposit over two periods becomes:

$$\text{Max } (1+b_2) \times (b_1-d_1) \times D_1(d_1) + (b_2-d_2) \times D_2 \, (d_1, d_2) . \tag{6}$$

The optimal condition for the deposit rate becomes:

$$d_1 \times (1+ \eta_1^{-1}) = b_1 + \frac{(b_2 - d_2)}{1+b_2} \times \frac{\partial D_2 / \partial d_1}{\partial D_1 / \partial d_1} . \tag{7}$$

One keeps the equality between the marginal cost of deposits and the marginal return. The marginal return incorporates not only the current matched-maturity market rate, but also the marginal profit on next-period deposits.

The second dynamic case concerns the situation of interest rate rigidity or stickiness. This is

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[9]Rate stickiness is only discussed in the context of deposit pricing. A similar reasoning applies in the case of other products with rigid pricing, such as credit card loans (Ausubel,1991).

particularly relevant for products such as savings deposits. Assume that the interest rate is fixed over two periods, then :

$$\text{Max } (1+b_2) \times (b_1-d_1) \times D_1(d_1) + (b_2-d_1) \times D_2(d_1) . \tag{8}$$

The first-order condition is :

$$d_1[D_1'(1+\eta_1^{-1}) + D_2'\frac{1+\eta_2^{-1}}{1+b_2}] = D_1'b_1 + D_2'\frac{b_2}{1+b_2} . \tag{9}$$

The elasticity (return) of the single period optimum is replaced by a weighted sum of current and future elasticities (return), the weights being the discounted supply derivatives.

An important conclusion for pricing is that, once dynamic features are introduced in the neoclassical model, it becomes clear that the appropriate marginal income on savings deposits is not the short-term rate, but rather a weighted sum of current and future interest rates. On operational grounds, the choice of the relevant maturity for the benchmark becomes important in the case of non-flat yield curves. This is clarified in Appendix A, in which we argue that one should distinguish among three separate applications for the choice of the relevant benchmark maturity: the pricing of products, the choice of the hedge instruments, and the selection of a transfer price to evaluate *ex post* the performance of the branch.

5.3 A valuation model of the banking firm : no tax, no risk, no growth

The neoclassical microeconomic model of the banking firm presented above provides some useful tools to price deposits and loans, and to evaluate *ex post* the profitability on loans or deposits. From a finance perspective however, it is not totally satisfactory, as it is not rooted in valuation. In the light of the fact that management wants to maximize shareholder value, one would need a valuation-based modelling approach for the banking firm. The valuation model of the banking firm will be presented step by step, from simple cases with no tax, no risk, no growth, to more complete models with tax and risk. It is based on Dermine (1985a, 1987), and Dermine and Hillion (1992).

We assume, for expository convenience, that a bank has two more years to survive before it is liquidated. The bank has, on its asset side, a portfolio of two-year-to-maturity loans (L) and

bonds (B) which have been acquired in the past and which carry fixed interest rates, respectively p and b. These assets are financed with deposits (D) and equity (E). Deposits have a maturity of two years, offering a fixed interest rate d. Loans, bonds and deposits are recorded at their historical book values, L, B and D respectively. The current one-year return on similar assets and liabilities are respectively p^*, b^*, and d^*, constant over the next two years. Since this section does not focus on risk, all the variables are to be taken as certain or certainty equivalent. As in the neoclassical model outlined earlier, the bonds and equity markets are assumed perfectly elastic, and the (certainty equivalent) cost of equity is the current market bond rate b^*. The balance sheet of the bank is given below :

<div align="center">

Loans L(p)   Deposits D(d)

Bonds B (b)   Equity E (b^*)

Balance Sheet

Notes : Two-year-to-maturity fixed rate assets and deposits.
Historical rates on loans, bonds and deposits are p, b, and d.
Current rates on loans, bonds and deposits are p^*, b^*, and d^*.

</div>

There can be many reasons as to why we observe an interest rate differential between assets and liabilities. The longer maturity of assets may command a risk premium and, with deposits withdrawable at short notice, the posted deposit rate does not include the extra cost of refinancing the bank in the case of deposit withdrawals. However, this does not explain the differential in the model. We have assumed that the return and cost, p^* and d^*, are net of the price for risk, and we postulate that it is imperfect competition or regulation on some markets which creates the interest rate differentials. Barriers to entry or regulation (such as regulations on interest rate paid on demand deposits) prevent the creation of perfect substitutes which would erase the interest rate differentials. The relevance of imperfect competition can be questioned in a period of global deregulation, but it would seem that market concentration due to bank mergers or asymmetric information can create imperfections in at least some markets. In any case, the model is quite general as perfect competition will appear as a special case.

The growth path of assets and liabilities must be defined to close the model. We assume, for simplicity, that the assets and liabilities are constant in book value terms over the next two years, and that the accounting profit (the net interest income) is paid out as dividends. The subscripts *1*, *2* and *3* will indicate respectively the beginning of the first and second period, and the end of the second period.

The market value of the equity of the bank (MV) is the discounted value of the dividends and liquidation value at the end of Year 2, discounted at the shareholders' opportunity cost of funds, b* (the cost of equity).

$$MV = \frac{pL + bB - dD}{1 + b^*} + \frac{(1+p)L + (1+b)B - (1+d)D}{(1+b^*)^2}.$$

(10)

This relation can be expressed in a more cumbersome but very meaningful way (see the proof in Appendix B).

$$MV = L_1^* + B_1^* - D_1^*$$

$$+ \left[\frac{(p^* - b^*) \times L_1^*}{1 + b^*} + \frac{(p^* - b^*) \times L_2^*}{(1 + b^*)^2} \right]$$

$$+ \left[\frac{(b^* - d^*) \times D_1^*}{(1 + b^*)} + \frac{(b^* - d^*) \times D_2^*}{(1 + b^*)^2} \right]$$

(11)

where L_i^*, B_i^* and D_i^* are the current economic values in Year i of the loans, bonds and deposits evaluated at the current loan, bond and deposit rates. For instance, the economic values of loans at the beginning of their respective periods are respectively :

$$L_1^* = \frac{pL}{(1 + p^*)} + \frac{(1+p)L}{(1 + p^*)^2}$$

(12)

$$L_2^* = \frac{(1 + p)L}{(1 + p^*)}.$$

(13)

The market value of the bank is the sum of two terms: the difference between the economic

value of assets and liabilities evaluated at their respective current rates and the franchise value. The franchise value represents the ability to pay below market rates on deposits and the ability to charge above market rates on loans. We have assumed implicitly that $p^* > b^* > d^*$. This is to be expected if financial intermediaries are to exist, but it needs not to be observed for each single asset and liability.

The current economic value of deposits and loans D_i^* and L_i^* can be interpreted as their liquidation (reimbursement) value if these liabilities and assets are valued at the depositors's and borrowers's opportunity cost of funds (d^* and p^* respectively). For instance, a demand deposit with contractually a very short term maturity would always be valued at par, while a fixed-rate term deposit could be valued above par if the current deposit rate has fallen. The economic values of loans represent the values from the borrowers' perspective, that is the amount they would be willing to pay back immediately to the bank if they were able to borrow again at the current rate p^*.[10] This presentation allows us to distinguish between the value of equity on a *liquidation* basis and the value of the bank as a *going concern*. The liquidation value is equal to ($L_1^* + B_1^* - D_1^*$), while the going concern value entails a second term, the value of the franchise, i.e. the ability of the bank to earn rents in the future. Solvency of banks must be evaluated as the greater of the *liquidation* and *going concern* values. This was already noted by Paul Samuelson many years ago (1945, p24): "It should not be necessary to argue before economists that the banking system is a going concern and should be treated as such".

In anticipation of the discussion on interest rate risk in Section 6, one can see that the market value of a bank will be affected not only by changes in value of assets and liabilities, but also by the impact of interest rate on the franchise value.

It can be shown that in a multi-period model, the valuation formula becomes

$$MV = L_1^* + B_1^* - D_1^* + \sum_{t=1}^{\infty} \frac{(p_t^* - b_t^*) L_t^* + (b_t^* - d_t^*) D_t^*}{\prod_{t=1}^{\infty} (1 + b_t^*)}. \tag{14}$$

5.4 A valuation model of the banking firm with taxes (no risk)

Corporate taxes are likely to affect the value of the bank for two reasons. The first one is that the

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[10]These economic values are identical to the *fair* value of financial instruments reported by US banks (SFAS 107 on "Disclosures about Fair Value of Financial Instruments").

cost of equity is not tax deductible, and the second is that capital gains (losses) on assets are taxed only when realized at the corporate level. The importance of the tax treatment of capital gains (losses) appears to have been somewhat ignored, as the accounting rule SFAS 107 on *fair value accounting* does not take them into account.

We assume that all the assets and deposits have ben acquired at par, so that only accounting income (net interest margin) is being taxed. Denoting by *t* the corporate tax rate, we obtain the following valuation formula for the shares of the bank :

$$MV = \frac{(1-t)x(pL + bB - dD)}{1+b^*} + \frac{(1-t)(pL + bB - dD) + L + B - D}{(1+b^*)^2}.$$

(15)

Following the proof reported in Appendix C, we obtain a quite meaningful formula :

$$MV = L_1^* + B_1^* - D_1^*$$

$$+ \left[\frac{(p^* - b^*)x L_1^*}{1+b^*} + \frac{(p^* - b^*)x L_2^*}{(1+b^*)^2} \right] + \left[\frac{(b^* - d^*)x D_1^*}{(1+b^*)} + \frac{(b^* - d^*)x D_2^*}{(1+b^*)^2} \right]$$

$$+ \left[-\frac{tb^* E_1^*}{1+b^*} - \frac{tb^* E_2^*}{(1+b^*)^2} \right]$$

$$+ \left[\begin{array}{l} \dfrac{t(L_2^* - L_1^*)}{1+b^*} + \dfrac{t(L_3^* - L_2^*)}{(1+b^*)^2} + \dfrac{t(B_2^* - B_1^*)}{1+b^*} + \dfrac{t(B_3^* - B_2^*)}{(1+b^*)^2} \\ -\dfrac{t(D_2^* - D_1^*)}{1+b^*} - \dfrac{t(D_3^* - D_2^*)}{(1+b^*)^2} \end{array} \right]$$

(16)

The market value is the sum of four terms: the current value of assets net of the liabilities (the

liquidation or economic value of equity), the after-tax value of the franchise on deposits and loans, the present value of the non-tax deductibility of equity cost (the M&M corporate tax penalty, Modigliani and Miller, 1958), and the present value of the tax savings due to the non-taxation of capital gains/losses on assets (liabilities) over the life of these assets (liabilities).

This valuation formula requires some explanatory comments. The current economic values of assets and liabilities L_i^*, B_i^*, and D_i^* are the 'true' economic values as defined by Samuelson (1964), that is the present value of after corporate tax cash flows discounted at the after corporate tax discount rate ($p^*(1-t)$, $b^*(1-t)$, and $d^*(1-t)$, respectively) where taxes are paid on current capital gains and losses. Equivalently, given Samuelson's Invariance Theorem (1964), they are the present value of the before-tax cash flows discounted at the before-tax discount rate. We call these true economic values, S values. The first term in the valuation formula is the S equity, that is the difference between the S value of assets and liabilities. The second term is the after-tax franchise, that is the ability to pay below market rate on deposits, and to charge above market rate on loans. The third term is the non-tax deductibility of the cost of the S equity. One will notice that the economic value of equity is not constant during these two years because the current S value of assets and liabilities changes over time. The last set of terms takes into account the specific tax treatment of capital gains and losses on assets and deposits. They were not taxed, in our example, so that the the present value of the tax savings (losses) must be included in the market value. The assumption of not taxing the unrealized capital gains and losses was made for expository convenience. This leaves room for tax management with losses to be taken immediately and gains realized only later to maximize the tax shelter. A very practical implication of this valuation formula is that one must consider the tax status of assets to measure the true value of a fixed-income portfolio (for instance, fixed-rate mortgages) when interest rate goes up. There can be a substantial difference between the discounted value of before-tax cash flows at the before-tax discount rate (i.e. the Samuelson S value) and the value of these assets for the bank's shareholders. These assets are worth much more to shareholders of the bank than to any investor in the market, because only the (low) interest income is taxed, while the capital gain earned over the life of these assets as they reach maturity will be tax-free (unless they are realized).

To summarize, the determinants of the market value of the bank include the S value of economic equity, the after-tax value of the franchise, the tax penalty on equity, and the present value of tax savings on unrealized capital gains. This presentation was chosen to highlight explicitly the determinants of the market value, with reference to SFAS 107 which suggests calculating the fair value of assets and liabilities on a before -tax basis (i.e. the S true economic value). This creates a need to consider explicitly the tax benefits on capital gains/losses.[11]

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[11]An alternative way to calculate the market value of the equity of a bank is to value the economic value of assets and liabilities as the present value of after-tax cash flows

The growth of a bank's assets and deposits has been ignored. As shown in Dermine (1985b,1987) and in Dermine and Hillion (1992), the framework can be extended for real growth and inflation by simply replacing A_i^* by the current value of assets (deposits) in Year i, which may incorporate some old assets at their current value plus new assets booked into that period.

So far, risk and its effect on the choice of a risk-adjusted discount rate for a bank, has been ignored. This is discussed in the next section.

5.4 A valuation model of the banking firm : Corporate tax and Risk

The framework has ignored risk and the difficulty of choosing a *risk-adjusted* discount rate to value assets and liabilities. Standard corporate finance theory suggests discounting dividends at the cost of equity. This one is calculated as the expected return on the bank share, which can be estimated with a standard CAPM or a discounted dividend model (Brealey, Meyers, and Allen 2006). As an illustration, the *betas* of the shares of several European and American banks are reported in Table Three:

BNP-Paribas	0.94	J.P. Morgan Chase	1.57
Société Générale	1.08	Citigroup	1.17
ABN-AMRO	1.25	Wells Fargo	0.13
ING Groep	1.48	Bank of America	0.55

Table Three: Beta of Banks' Shares
Source: Thomson Analytics (December 2005)

Whenever the risk of specific assets is different from that of the average bank, the standard corporate finance text-book recommends finding, in the stock market, shares of firms with similar risk as the one analyzed. For instance, in the case of a conglomerate firm with businesses in the

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discounted at the after-tax asset- specific rate, where the after-tax cash flows do not include the tax on capital gains. In this case, the tax benefits are directly incorporated in the current value, and the last term in the valuation formula, the value of the tax savings on unrealized capital gains, disappears.

chemical sector and in other sectors, one recommends using, as the cost of equity to evaluate projects in the chemical sector, the expected return on shares of companies specialized in the chemical sector. In principle, with a bank having assets with different types of risk, from very safe to very risky, one could be tempted to make a similar recommendation. Specialist banks, also called monolines, such as credit card providers (e.g., Capital One), global custodians (e.g., State Street, Bank of New York), or private banks (Vontobel in Switzerland) can help to estimate a risk premium specific to some activities of a universal bank. However, the standard 'corporate finance' recommendation is very unlikely to work for bank lending, for the reason that, on the stock market, specialized banks lending to just one business sector one are not easy to find. It is for this reason that banks often use one common average cost of equity to evaluate different activities, the expected return on the bank's own shares (Zaik *et al.*, 1996). In this section, we propose a methodology to take into account specific risk-adjusted discount rates.

Let us consider the equity of a bank invested into loans. We focus on one asset for expository convenience and further assumes that it is a perpetual loan. The single asset approach is generalized next.

We define:

L = loan (perpetuity)

p = expected return on loan

t = corporate tax rate

p^* = expected return on new loan

b^{**}= shareholders' opportunity rate

The balance sheet of this position is as follows :

$$\text{Loan } L(p) \quad \text{Equity } (b^{**})$$

We argue that, rather than searching for banks specialized in lending to a single business sector to recover the *beta* of their shares and the relevant risk premium, an alternative would be to use the *expected return on corporate bonds of similar risk* as an opportunity cost for the banks' shareholders. In other words, to value a loan to a particular business sector with a specific credit grade, one could use information from the corporate bond market.

We are now equipped to value the equity of this bank. It is the present value of the (perpetual) flows of dividends discounted at the shareholders' opportunity rate :

$$MVof\ Equity = PVof\ dividends = \frac{(1-t)\ x\ p\ x\ L}{b^{\bullet}}$$

It can be shown to be equal to :

$$MarketValue = \frac{(1-t)pL}{(1-t)p^*} + \frac{(1-t)(p^* - b^{**})L^*}{b^{**}} - \frac{tb^{**}L^*}{b^{**}}$$

$$= L^* + \frac{(1-t)(p^* - b^{**})L^*}{b^{**}} - \frac{tb^{**}L^*}{b^{**}}.$$

(17)

This formula is similar to the one discussed earlier. The value of the equity is the sum of three terms: the value of the loan after-tax cash flows discounted at the loan after-tax current rate, the after-tax value of the franchise, and the Modigliani-Miller tax penalty. The valuation formula highlights that the relevant opportunity rate should be the expected rate on a corporate bond with similar risk as the loan (b^{**}).[12]

Although the availability of data on expected return on corporate bonds is currently not as widely available as data on expected return on shares, one can expect that, with the growth of corporate bonds and asset-backed securities markets, more information will be available on the expected return on corporate bonds. For instance, a study by Delianedis and Santa Clara (1999) provides the following information :

	USA	Germany	United Kingdom
AAA	117bp	- 7	280
AA	260 bp	209	260
A	200 bp	58	280
BAA	360bp	140	320

Table Four : Excess Return (basis points) on Corporate Bonds (1993-1997)
(actual return on corporate bonds - return on Federal bond)
Source : Delienadis and Santa-Clara (1999).

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[12]There is no term for the unrealized capital gains/losses, as the value of the perpetual loan is constant.

If one repeats the same approach for bonds and deposits, and applying the principle of value additivity of Modigliani and Miller (1958), one obtains :

$$MV = L_1^* + B_1^* - D_1^* \tag{18}$$

$$+ \left[\frac{(1-t)x(p^* - b_L^*)xL_1^*}{1+b_L^*} + \frac{(1-t)x(p^* - b_L^*)xL_2^*}{(1+b_L^*)^2} \right]$$

$$+ \left[\frac{(1-t)x(b_D^* - d^*)xD_1^*}{(1+b_D^*)} + \frac{(1-t)x(b_D^* - d^*)xD_2^*}{(1+b_D^*)^2} \right]$$

$$- \left[\frac{tb_L^* L_1^*}{1+b_L^*} + \frac{tb_L^* L_2^*}{(1+b_L^*)^2} \right] - \left[\frac{tb^* B_1^*}{1+b^*} + \frac{tb^* B_2^*}{(1+b^*)^2} \right] + \left[\frac{tb_D^* D_1^*}{1+b_D^*} + \frac{tb_D^* D_2^*}{(1+b_D^*)^2} \right]$$

The value of the equity is the value of the net assets discounted at the after-tax one-period asset specific discount rate (b_L^*, b_D^*, and b^*) plus the after-tax franchise value on loans and deposits, plus the tax penalty on assets and tax savings on deposits.

This valuation formula can be compared to the results of the neoclassical model discussed earlier. While that model, focused on economic profit, had identified the relevant transfer price as being the matched-maturity marginal value of funds (MMMVF), the market rate on the interbank or bond markets, the valuation formula states that banks should attempt to increase their franchise value net of a tax penalty, and that the relevant opportunity rate is the *expected return on bonds* with a similar risk as the asset under review.[13] Transfer prices used for pricing or for profit

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[13]As an alternative to the expected return on corporate bonds, one could attempt to estimate a beta with reference to CAPM theory : beta $_i$ = Cov $(R_i, R_M)/\sigma^2_M$). In the absence of empirical evidence from bank shares, the covariance can be estimated with the correlation between the accounting income or cash flow of a specific business and the market return. The key difference with our approach is that the expected return on corporate bonds can be estimated directly from market data, while the alternative 'beta' approach makes the strong

evaluation could therefore be differentiated according, not just to maturity, but also to credit risk. One can guess that, for assets with very low credit risk, this should not be much of an operational issue, as the beta and risk premium on this type of corporate debt must be small. However, for risky loans, the beta and risk premium could increase significantly (Kaplan and Stein, 1990).

implicit assumption that the CAPM holds.

Section 5: Application I, Pricing Loan and Loan Loss Provisioning

The bank valuation framework presented above provides an integrated framework to discuss several ALM issues. In this section, we apply the model to the pricing of loans and to the calculation of fair credit risk provisions. In the following sections, it will be used to discuss the measurement of interest rate and liquidity risks, and also the aggregation of risks.

With regard to lending, two separate issues need to be distinguished. The first one occurs at the origination date of the loan at time 0. What is the break-even interest rate on the loan ? A second issue occurs one year later. The interest on the loan has been paid, and a question arises as to how much loan provisions one should create or, equivalently, how one should measure the risk-adjusted profit at the end of the first year. This last issue is of great managerial relevance as, if no provisions were created early, there could be a temptation to go into high margin and high risk lending with a view to showing large profit in the early years.

5.1 The Pricing of Loans

To calculate the break-even interest rate on a risky loan, three types of data are needed: the funding structure (equity vs. debt), the probability of default over time, and the loss given default (LGD). The first one concerns the amount of equity needed to fund the loan. In line with standard practice (Basel Committee, 2003), banks, to ensure their solvency, need to provide enough equity to cover potential loan losses in case of a severe recession. This equity cushion is referred to as *economic* or *risk-based capital*. Potential loan losses can be measured in two ways: change in value of the loan (marked-to-market mode, MTM), or the cost of a default (default mode, DM) over a specific time interval, which is one year in many banks. The change in value is the most comprehensive approach as it recognizes not only the states of default, but also the loss of value resulting from a downgrade or upgrade of the counterparty. The second approach (default mode) recognizes only two states of the world: default or no-default. Potential losses are evaluated with a certain threshold of confidence, such as 99.9 %. The second set of data concerns the probability of default over time. The third, and final, parameter is the estimate of the losses in case of default (loss given default), which includes not only data on recovery, but also on the tax shield on losses that will be recognized by tax authorities.

A complete coverage of the, rapidly expanding, credit risk literature is outside the scope of this chapter.[14] In summary, three approaches are used to estimate the risk of default. First, one based on a collection of historical data for different risk grades. The second approach attempts to model the stochastic process of latent variables that drive the default event. The application of option pricing (Merton, 1974) to evaluate credit risk has led to successful commercial applications (e.g., Kealhofer, 1995 ; KMV, 2002). A third approach estimates directly the probability of default from observed bond prices and volatilities (Duffie and Singleton, 1999).

Let us consider the following example of a loan with two-year-to-maturity:

- €100 M two-year-to-maturity fixed rate loan (interest paid at the end of the year and principal at maturity)
- Corporate tax rate of 40 %
- Expected return on one-year and two-year-to- maturity similar risk (zero coupon) corporate bond of 10.1 % and 10.2 %, respectively.
- Fixed interbank rate of 10 % for the first year, and 10 % for the second year
- Equity (economic capital) funding : 6 %
- Interbank funding : 94 %
- Probability of default in Year One : 0 %
- Probability of default in Year Two : 3 %
- Loss Given Default = 40 (i.e., recovery of 60 in case of default).

The break-even loan interest rate, R, is such that the discounted value of expected cash flows is equal to the initial equity investment,

$$Equity = 6 = \frac{R \times (1 - 0.4)}{1.101}$$

$$+ \frac{0.97 \times [R \times (1 - 0.4) + 100] + 0.03 \times [60 + 0.4 \times 40]}{1.102^2} \qquad (19)$$

$$- \frac{94 \times 0.10 \times (1 - 0.4)}{1.1} - \frac{94 \times 0.10 \times (1 - 0.4) + 94}{1.1 \times 1.1}.$$

The expected cash flows from the loan in Year 2 comprises two parts: The expected revenue in the case of non-default, and the recovery plus the tax shelter created by the losses in the case of default. The cash flows from the loan are discounted at the expected return on corporate bonds, the opportunity return available to shareholders, while the cash flows from the debt are discounted at the current debt rate. The break-even loan rate, R=11.45 %, will capture implicitly the funding structure, the probability of default, the expected losses arising out of default, and the opportunity expected return on corporate bonds.[15] A separate, but related, issue will concern the creation of fair credit risk provisions over the life of the asset.

5.2 Fair provisioning

The issue of fair provisoning for credit risk is a very important one in banking for two reasons. The first one concerns the estimate of solvency of a bank and the need to measure properly its equity. Instead of waiting for problems to occur, one would want to recognize earlier the loss of value of assets to force a bank to reduce dividends and/or to increase its equity base. The second issue concerns the creation of proper incentives inside a bank. If provisions are not recognized early, there would be a *myopic* temptation to go into high risk- high margin lending to show very good profit and performance early, especially when rewards and bonuses are linked to performance. So, to reduce this eventual bias, the creation of early provisions would help to reduce the apparent profit. Whatever the reason, solvency or risk-adjusted performance evaluation, there is a need for a proper methodology to measure provisions. We argue that the value-based model allows a level of fair provisions to be created, fully consistent with finance theory. Consider the example of the previous loan, priced at 11.45 %. At the end of Year 1, the interest rate has been collected and the issue concerns the proper calculation of provisions, and the evaluation of the performance of the loan officer.

For the sake of the example, imagine that one year later, the parameters remain unchanged.

● € 100 M two-year-to-maturity fixed rate loan (interest, 11.45 %, paid at the end of the year, and principal paid at maturity)
● Corporate tax rate of 40 %
●Expected return on one-year-to-maturity similar risk (zero coupon) corporate bond

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[15]We refer to this loan pricing approach as EVAL, economic value added in lending. It allows us to calculate the break-even rate on a loan transaction (Dermine, 1995 and 1998) .

of 10.2 %

● Fixed interbank rate of 10 % for the second year

● Equity funding : 6 %

● Interbank funding : 94 %

● Probability of default in Year Two : 3 %

● Loss Given Default : 40 (i.e. recovery of 60 in case of default).

We propose to follow a marked-to-market approach, recognizing the change in fair value of the loan.

Provisions = Δ Net Loan Value = Δ (value of loan - value of debt)

$$Net\ Loan\ Value = \frac{0.97x(100 + 11.45x(1 - 0.4)) + 0.03x[60 + 0.4x40]}{1.102}$$

$$- \frac{94x0.10x(1 - 0.4) + 94}{1.1} \qquad (20).$$

$$= 96.138 - 90.582 = 5.556.$$

Since the net value of the loan is € 5.556 million at the end of Year 1, when it was € 6 million at the beginning, one calculates the provisions as the change in net value over the year:

Provisions = 6 - 5.556 = 0.444.

The *risk-adjusted* profit on the loan, and the economic profit (EP) are calculated as follows :

Profit = after-tax interest margin - provisions
= (1-0.4) x (11.45 - 10% x 94) - 0.444 = 1.224 -0.444 = 0.78

Economic Profit = Profit - cost of allocated equity = 0.78 - (6 x 13.2%) = 0.

The economic profit is zero in this example. This is to be expected as the loan rate of 11.45% was chosen as the break-even loan rate that would given shareholders the minimum required return on their investment. One notices that the methodology used to calculate the fair provisions is identical to that used to price loans. On a technical note and contrary to common belief, one

observes the creation of provisions in Year 1, although the probability of default remained unchanged (at 3%). The intuition is that the high break-even rate of 11. 45% was needed to cover the expected cost of default in Year 2. Of course, the level of provisions would increase further if, in the event of a recession looming, the estimate of probability of default and/or the estimate of the recovery were being revised. There is a widespread debate on fair provisions (Bank for International Settlements, 1991), and the fear that accounting manipulation could lead to under reporting.[16]

To close this section, one needs to clarify the conceptual difference between the loan provisions proposed above, and the practice of some banks which compute provisions as the present value of expected losses. This last measure is related to our change in net value, but it includes only the expected losses, while the change in market value will take pricing into account. We argue in favor of the change in market value as, not only is it consistent with value-based finance, but it also provides a common methodology to evaluate performances across the bank on a marked- to-market basis.

The first application of the bank valuation model was concerned with loan pricing and the creation of fair provisions for credit risk. We next turn to what was traditionally the corner stone of ALM in a bank, that is the measurement of interest rate and liquidity risks.

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[16]The official estimate of bad loans held by the top 15 Japanese banks in 2001 rose to ¥ 20,700 bn (4% of gross domestic product). Analysts say that the real figure could be seven times this amount (Financial Times, 13 December 2001).

Section 6: Application II, The Measurement of Interest Rate and Liquidity Risks

The measurement of interest rate and liquidity risks on the banking book of a bank has had a central place in ALM. Early studies include Stigum and Branch (1983), Platt (1986), Farin (1989), and Fabozzi and Konishi (1991). The consensus is that banks should focus on two approaches to measure interest rate risk (Haupt and Embersit, 1991 and 1997; Basle Committee, 1997; Dermine and Bissada, 2002). The first approach to measure interest rate risk is concerned with the impact of a change of interest rate on the Profit & Loss account, that is the impact on the net interest income (NII) of the bank. The second approach focuses on the impact of a change in interest rates on the fair economic value of the equity of a bank. The two alternative approaches will be discussed consecutively.

6.1 Net Interest Income at Risk

The Income Statement of a reprentative bank, the Royal Bank of Canada, was introduced in Section 2. In the year 2000, it reported a net interest income of Can\$ 5,279 million and a total non-interest revenue (fees, trading profit) of Can\$ 6,680 million. Although the second source of revenue - fee income- has increased over the years, it remains that the net interest income of most banks is still a very substantial part of revenue. Therefore, a lot of emphasis is placed on the control of the net interest margin.

To evaluate the impact of a change in interest rate on the net interest margin of a bank, banks compute a repricing gap table, also called an interest rate sensitivity table. The time scale is broken into discrete time buckets, for instance quarters[22] : 1, 2, ... Considering the balance sheet of the bank at a specific date t, one measures the stock of assets and debt that will be repriced at time $t + i$ (i=1 to N), respectively A_{t+i} and D_{t+i}, if there is an instantaneous movement in the yield curve at time $t + \varepsilon$. For instance, a one-quarter Treasury Bill and a floating rate loan repriced every quarter would be slotted into the one-quarter bucket. A five-year-fixed rate bond would be slotted in the five-year bucket. A representative repricing gap table follows :

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[22]The length of the time bucket -a quarter- is arbitrary, being chosen for expository convenience. Banks, in a very volatile environment, should work with finer buckets: daily or weekly.

	Roll-over date or nearest interest rate adjustment date (Can$ million)					
	Sight up to 3 month	**> 3 months < 6 months**	**>6 months <1 year**	**1 to 5 years**	**over 5 years**	**Non-interest sensitive**
Assets	121,95	14,377	16,158	70,186	11,48	55,589
Loans						
Bonds						
Other assets						
Liabilities	156,198	13,602	18,852	32,52	8,523	60,045
Deposits						
Bonds						
Equity						
Off-balance Sheet	16,656	-1926	-6378	-3284	1204	-6272
Repricing Gap	-17,592	-1,151	-9,072	34,382	4,161	-10,728
Cumulative Gap	-17,592	-18,743	-27,815	6,567	10,728	0

Table Five: Repricing Gap Table

Source: Royal Bank of Canada, Annual Report 2000.

Assuming that the roll-over (reinvestment of the asset) takes place over a quarter,[23] a positive cumulative gap indicates that there will be a net excess of assets to reprice in the coming quarter, while a negative cumulative gap indicates an excess of deposits to reprice. In the case of an increase in the interest rate curve, a positive cumulative gap will help the bank to increase its net interest margin, while a negative cumulative gap would generate a loss of net revenue. With reference to Table Five, the negative gaps run by the Royal Bank of Canada imply that the bank would benefit from a fall in interest rate.

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[23]Note that the one-quarter roll-over at the one-quarter forward rate is not a restrictive assumption. Indeed, the roll-over over two quarters at a two-quarter rate is, by definition of the six-month forward rate, equivalent in present value terms to a series of one quarter-roll-overs. Of course, the cash flow and net interest margin in any particular quarter would be affected by the choice of the re-investment strategy, but not their present value.

Let us define the current curve of forward rates as R_1, R_2, R_3..... Formally, the change in the net interest margin at time $t+n$ for a change in the forward rate ΔR_{t+n} is equal to :

$$\Delta \text{ Net Interest Margin}_{t+n} = \sum_{i=1}^{N} A_{t+i} \times \Delta R_{t+n} - \sum_{i=1}^{N} D_{t=i} \times \Delta R_{t+n}$$

$$= \sum_{i=1}^{N} (A_{t+i} - D_{t+i}) \times \Delta R_{t+n} = \text{Cumulative Gap}_{t+n} \times \Delta R_{t+n} . \qquad (21)$$

Banks have introduced the powerful concept of Earnings-at-Risk (EAR) to indicate the potential impact of an adverse change of interest rate on the P&L account of a particular quarter:

$$\text{EAR}_{t+n} = \Delta \text{ Net Interest Margin}_{t+n} = \text{Cumulative Gap}_{t+n} \times \Delta R_{t+n} . \qquad (22)$$

Once, a repricing gap table has been tabulated, an immediate question concerns the relevant change of interest rate (ΔR_{t+n}) that should be chosen to measure earnings-at-risk. Banks often report two measures of risk. A first measure evaluates the risk for a confidence interval of 99 %. This measure indicates that the potential loss would be underestimated in 1 % of cases. A second measure of risk concerns the measure of risk for rare big shocks (often referred to as 'stress scenario'), that is an attempt to measure risk for those cases in the one percent interval.[24]

$$\text{EAR}_{t+n, 99\%} = \text{Cumulative Gap}_{t+n} \times \Delta R_{t+n,99\%}.$$
$$\text{EAR}_{t+n,\text{Stress}} = \text{Cumulative Gap}_{t+n} \times \Delta R_{t+n,\text{stress}}.$$

The repricing gap table provides a first tool to measure the interest rate risk of a bank. It must be completed with the use of a simulation model for several reasons. First, such a table only gives information on the current structure of assets and liabilities. It ignores the dynamic changes in volumes of business over time. Indeed, the volumes of future loans or deposits could be affected by a movement in the yield curve. For instance, the volume of corporate demand deposits and retail consumer loans are likely to decrease when interest rates tighten up. Second, the earnings-at- risk calculation implicitly assumes that interest rates on assets and liabilities will adjust by the same percentage change as the change in the market yield curve. It ignores the interest rate elasticity which could be very different from 1. This is particularly the case in the retail market

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[24]A review of volatility forecasts can be found in Figlewski (1997). Discussion of stress testing can be found in Longin (2000) or in Committee on the Global Financial System (2001).

with savings deposits or consumer loans. It is, indeed, well known that some deposit rates and credit rates can display a fairly low elasticity. In general, the absence of perfect correlation between two interest rates in the same bucket is referred to as *basis risk*. In order to take into account the impact of a change of interest rates on future volumes of business and the imperfect correlation between some interest rates, simulation models have been developed (Platt, 1984). Although Monte Carlo simulations could in principle generates thousands of scenarios, banks usually consider few scenarios (around a dozen) that take into account several movements in the market yield curve and various responses of volumes or interest rates. Finally, various products can have embedded options. A classical example is the pre-payment option on a fixed- rate long-term mortgage. Although, the loan is unlikely to be pre-paid in the case of a rising rate environment, this would not hold in the case of a decreasing interest rate. As is the case with options, one loses the symmetry between the effect of an increase and a decrease in interest rate. Simulation of pre-payment under various interest rate scenarios can help to capture this complexity.

Several weaknesses of repricing gaps or bank simulation models have been identified (Dermine, 1991a and 1993). Repricing gaps most often ignores the payment of interest/coupons and taxes. Fixed income instruments should be treated as a series of zero coupon instruments with different maturity dates. Most often, floating rate assets/deposits are slotted into the first quarter gap. This ignores the fixed spread on the floating rate which creates the equivalent of a fixed rate annuity (Dermine, 1991b). Last, but not least, is the inappropriate treatment of equity. Indeed, equity is most often slotted into the last bucket (non-interest sensitive), as if its cost was not sensitive to interest rate. This is correct from an accounting and net interest income perspective as the cost of equity is not included in a P&L account. However, from a finance perspective, the correct measure of profitability should be an economic profit which takes away from net income the opportunity cost of equity. As the estimate of the cost of equity is based on the current opportunity return available on risk-free government bonds, one concludes that the cost of equity is interest sensitive, and therefore that equity should be included in the first bucket.[25]

The focus on the impact of interest rate on the net interest margin and the P&L account is understandable as bank analysts focus very much on ROE-based measures of performance. But, this measure risks the dangers of myopia if management focuses only on the short-term impact.

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[25]One observes here an inconsistency in bank practice. Many banks control the impact of interest rate on the net interest margin (ignoring the cost of equity capital), while they evaluate internally the performance of business units on an economic profit basis, that is net of a cost of equity capital.

Following the Savings & Loans Association (S&Ls) crisis in the United States in the early 1990's, increasing attention has been focused on the impact of interest rate on the change in the fair economic value of the equity of a bank. This is the second major approach to the measurement of interest rate risk on the banking book.

6.2 Economic Value at Risk

Following the large maturity mismatch, run by US S&Ls, between short-term retail deposits and long-term fixed rate mortgages, bank supervisors have been increasingly concerned with solvency and the need to ensure that the fair value of assets exceeds the fair value of debt. Defining the economic value of the equity of a bank as the difference between the value of assets and debt, one needs to calculate the impact of a change in interest rate on the economic value (EV) of equity.

Economic value of equity = EV = Value of assets - Value of debt   (23)

Δ Economic value of equity = ΔEV = Δ Value of assets - Δ Value of debt.

With A and D referring to the current value of assets and debt, Du_A and Du_D referring to the duration of asset and debt, and applying the MacAulay (1938) duration[26] formula to the change in value of assets and debt, one obtains:

Δ EV = [- A x Du_A / (1+R) X ΔR)] - [- D x Du_D / (1+R) X ΔR)]   (24)

Δ EV = - A X (Du_A - D/A Du_D)/(1+R) X ΔR

ΔEV/EV = - (A/EV) x [(Du_A - D/A Du_D) x 1/(1+R)] X ΔR   (25)

ΔEV/EV = - LEVERAGE X MODIFIED DURATION GAP X ΔR .

The last expression gives a very useful summary measure of interest rate risk, that is the percentage change in the value of the equity of a bank for a change in interest rates. It is the product of three factors: the leverage (assets over economic value), the duration mismatch

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[26]The MacAulay duration of a fixed-income asset is its weighted average maturity, the weight, applied to each date of a cash flow receipt, being the present value of that cash flow divided by the value of the asset.

between assets and liabilities, and the change in interest rate. Although the MacAulay duration applies only to a parallel shift in the yield curve, it can easily be extended to different twists in the yield curve with a *vector duration* approach (Chambers, Carleton, and McEnally, 1988), or a Value-at-Risk approach that will be discussed in Section 7.

If the above approach is adequate for assets traded on perfectly competitive markets, such as government bonds or subordinated debt issued by the bank, it raises the practical issue of the application of the duration concept to special accounts, such as demand deposits, savings deposits, or even credit cards loans. Indeed, if the contractual maturity of a demand deposit is extremely short as these deposits can be withdrawn on demand, the effective maturity is much longer as a core of deposits is likely to be stable. For banks collecting this kind of deposits, a question arises as to the choice of the effective duration of these accounts. Fortunately, the bank valuation model proposed in Section 4 will allow us to answer the question (Dermine, 1985a and 1993).

Let us consider the following valuation formula where, for ease of exposition, we focus on the franchise value of deposits, ignoring taxes and the franchise value on loans. The market value (MV) of the equity of the bank is the sum of the liquidation value and the franchise value:

$$MV = MV_A - MV_D + \sum_{t=1}^{\infty} \frac{(b-d)D}{(1+b)^t}.$$
(26)

Assuming for simplicity a constant perpetual franchise on deposits, one obtains,

$$MV = MV_A - MV_D + \frac{(b-d)D}{b}.$$
(27)

Since we are interested in the response of the franchise or charter value to a change in the market rates, we make the realistic assumption that the volume of deposits is a function of the deposit rate *d* and of the market rate *b* (D(d, b)) and that the deposit rate will respond to a change in the market rate.

The impact on the market value of a bank of a change in interest rate is given by :

$$\frac{\partial MV}{\partial b} = \frac{\partial MV_A}{\partial b} - \frac{\partial MV_D}{\partial d} \times \frac{\partial d}{\partial b} + \frac{\partial(\frac{(b-d)D}{b})}{\partial b}$$
(28)

that is, the effect of a market rate change on the market value of current assets, the effect of a consecutive change in the deposit rate on the market value of current deposits, and finally the effect on the franchise value or goodwill. This shows explicitly that the effective duration of a

demand deposits is a direct function of the sensitivity of the charter value to a change in interest rate. Often, because of the inelasticity of the deposit rate, the margin on deposits increases when the interest rate goes up. The total impact on the charter value is then related to the sensitivity of the volume of deposits. So the less competitive the market, the higher will be the charter value on deposits, and the larger is likely to be the effective duration of demand deposits.

The market value sensitivity can be expressed in a more operational form where the term η_{xy} denotes the elasticity of variable x with respect to y, i.e. the percentage change in the x variable to a percentage change in the y variable.

$$\eta_{MV,b} = \left(\eta_{MV_A,b} \times \frac{MV_A}{MV}\right) - \left(\eta_{MV_D,b} \times \frac{MV_D}{MV}\right)$$
$$+ \frac{\frac{(b-d)D}{b}}{MV} \times \left(\eta_{D,d} \times \eta_{d,b} + \eta_{D,b} + \eta_{\frac{b-d}{b},b}\right) \tag{29}$$

with $\eta_{MVA,b} = - Du_A \times b/(1+b)$, Du_A denoting the MacAulay duration of assets, and similarly, $\eta_{MVD,b} = - Du_D \times b/(1+b)$, Du_D denoting the MacAulay duration of deposits. Equation (29) states that the elasticity of the market value of equity to a change in the market rate is a weighted sum of elasticities. The weights are the current value of assets, deposits and the charter value as a percentage of total market value. The series of elasticities are as follows: the elasticity of the value of the asset with respect to the asset rate, the elasticity of the value of deposits with respect to the deposit rate times the elasticity of the deposit rate to the market rate, and finally a series of elasticities measuring the sensitivity of the charter value to a change in the market rate. Obviously, the smaller the franchise value or its sensitivity to the interest rate, the smaller is its relevance of the measurement of interest rate risk. This 'imperfect market' approach to the measurement of interest rate risk was applied in the case of deposits. It can be extended to any asset or debt with a franchise value.[27]

6.3 Hedging Interest Rate Risk

Potentially, two approaches can be used to hedge interest rate risk, commercial or financial. A commercial approach involves the choice of maturities or repricing dates for assets and deposits

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[27]Application of this methodology to other assets and stochastic yield curves can be found in O'Brien *et al.*(1994 and 2000), Hutchinson and Penacchi (1996), or Jarrow and van Deventer (1998).

to ensure matching. If this approach can be undertaken, it is often very costly as the restrictions on maturity and repricing terms can reduce profitability. Indeed, in some countries, consumers are used to fixed rate loans and short-term deposits. If a bank wishes to switch from fixed rate lending to variable rate lending, margin might suffer. For this reason, banks prefer to use financial instruments to manage their interest rate exposure. They could run an opposite mismatch on the interbank market or use financial derivatives, such as forward rates agreements (FRAs), financial futures, interest rate options,[28] or swaps. With regard to the use of derivatives, an additional difficulty has arisen recently. In the United States, the accounting rule, FAS 133, enforces the marked-to-market of derivatives.[29] This could create volatility of reported accounting income if the hedge instrument is marked-to-market, while the hedged position is accounted in the banking book at par value. At the international level, a similar debate arises with the International Accounting Standard (IAS) rule 39, which is to be implemented in 2005.

6.4 The Measurement of Liquidity Risk

In Section 1, we mentioned that one of the five main functions of a bank is to provide insurance, and that one type was liquidity insurance whereby depositors or borrowers are able to withdraw money on demand. This creates a liquidity risk for a bank. Moreover, on a day-to-day basis, banks must have enough liquidity to cover the payments made on the central bank's clearing system, such as Fedwire in the US or Target[30] in the European System of Central banks. This liquidity consists of: 1) balances with the central bank, 2) borrowing from other banks,
3) discount window borrowing from the central bank, and 4) expected incoming transfers from other banks.
A representative statement of cash flows of a bank is first presented. It allows to understand the various sources of cash inflows and outflows. A discussion of the measurement of liquidity risk follows.
The consolidated statement of cash flows presented below is that of the Royal Bank of Canada for the year ended October 31, 2000.

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[28]The management of interest rate options is beyond the scope of this chapter. Useful references include Jarrow (1996) and Rebonato (1996).

[29]Hedge accounting (matching the accounting rule of the hedge to the rule applied to the hedged instruments -marked-to-market or accrual) can be used under very restrictive circumstances.

[30]Target : Trans-European Automated Real-time Gross settlement Express Transfer system.

Cash Flows from operating activities (Can$ million)	
Net income	2,208
Adjustments to determine net cash provided (used in) operating activities	
Provision for credit losses	691
Depreciation	369
Restructuring	-
Amortization of goodwill and other intangibles	91
Gain on sale of assets	(4)
Change in accrued interest receivable and payable	110
Net loss (gain) on sale of available for sale securities	11
Changes in operating assets and liabilities	
Deferred income tax	(206)
Current income taxes payable	(434)
Unrealized gains and amounts receivable on derivative contracts	(4,183)
Unrealized losses and amounts payable on derivative contracts	3,355
Trading account securities	(11,078)
Securities sold with recourse	(312)
Obligations related to securities sold short	(5,867)
Other	97
Net cash provided by (used in) operating activities	-15,152
Cash flows from investing activities	
Change in loans	(11,728)
Proceeds from the maturity of held to maturity securities	500
Purchases of held to maturity securities	(114)
Proceeds from available for sale securities	10,525
Proceeds from the maturity of available for sale securities	16,269
Purchases of available for sale securities	(23,640)
Change in interest-bearing deposits with other banks	1,927
Net acquisitions of premises and equipment	(293)
Net proceeds from sale of real estate	-
Change in asset purchased under reverse repurchase agreements	1,969
Net cash used in acquisition of subsidiaries	(323)
Net cash used in investing activities	-4,908

Cash flows from financing activities	
Issue of RBC Trust Capital securities (RBC TruCS)	650
Increase in domestic deposits	8,818
Increase in international deposits	9,405
Issue of subordinated debentures	1,200
Subordinated debentures matured	(20)
Issue of preferred shares	-
Preferred shares redeemed for cancellation	-
Issuance costs	(4)
Issue of common shares	59
Common shares redeemed for cancellation	(660)
Dividends paid	(791)
Change in securities sold under repurchase agreements	(391)
Change in liabilities of subsidiaries	281
Net cash provided by financing activities	18,547
Net change in cash and due from banks	(1,513)
Cash and due from banks at the begining of the year	2,460
Cash and due from banks at end of year	947

Table Six: Consolidated Statement of Cash Flows (C$M)

Source: Royal Bank of Canada, 2000, Annual Report

The annual consolidated statement of cash flows starts with the net income of Can$ 2,208 million reported in the consolidated income statement discussed in Section 2. It then takes into account all the non-cash items included in the income statement, such as depreciation and provision for credit losses. Finally, it takes into account the cash flows linked to investing or financing activities. In banking, two items require a clarification: accrued interest receivable and payable, and the 'float'.

Interest income (expense) is generally recognized (accrued) as income (expense) over time even if it has not yet been paid. The following accounting relations have to be used to compute the actual net cash flows related to interest accruals:

$$\text{Accrued interest receivable (payable)}_{Oct.\ 2000} = \text{Accrued interest receivable (payable)}_{Oct\ 1999}$$
$$+ \text{ interest income (expense) accrual}_{2000}$$
$$- \text{ interest income (expense) actually paid}_{2000}.$$

The stock of accrued interest receivable (payable) at a specific date is equal to the stock of interest receivable (payable) a year earlier, plus the interest accruals of the year, minus the interest actually paid during the year. This relation allows the cash inflows (outflows) linked to interest accruals

to be calculated:

Cash inflow (outflow)$_{2000}$ = Interest income (expense) accrual$_{2000}$

$\qquad$ - Δ accrued interest receivable (payable)

Net cash flows$_{2000}$ = net interest accrual margin$_{2000}$ - Δ accrued interest receivable

$\qquad$ + Δ accrued interest payable.

In the RBC example, for instance, the net change in accrued interest receivable and payable created a positive cash inflow of Can\$ 110 million.

The second cash flow item to discuss is the 'float'. The practice of many banks is to credit (debit) deposit accounts several days after (before) the bank has actually received (paid) the cash. At any time t, the 'float' is a non-interest bearing source of funds, which represents the volume of deposits that have been debited 'early' or paid 'late' to clients because of the 'value date' system. An increase in the 'float', an item typically not disclosed by banks, represents, therefore, an additional sources of cash available.

An annual consolidated statement of cash flows was presented to identify the various sources of cash inflows and outflows. To control liquidity, i.e., the imperative to have cash available to meet, on a day-to-day basis, various commitments such as, for instance, payments of interest, reimbursement of deposits, or payment of taxes, the banks use an instrument very similar to the repricing gap table, except that the concern now is the amount of cash flowing in or out over a particular, very short-term time interval. One such table is constructed for 'normal' time, in which a large proportion of deposits, withdrawable on demand, remain with the bank. These are referred to as 'core' deposits. A second exercise is done for 'stress' time, during which the deposits outflow is much larger.

Cash Flow Gap (daily, weekly ...) for 'Normal Times' (Can$ million)

	Day One	Day Two	Day Three ....
Interest accrual income	44.1	46.2	
- Interest accrual expense	- 29.7	-28.3	
-/+ Margin calls	-1,000	-1,000	
- Operating Expense	-20.9	- 22	
- Tax	-3.9	- 3.9	
+ Δ Assets ('normally' maturing)	76.71	78.3	
- Δ Deposits ('normally' maturing)	- 15,000	- 1,000	
- Δ Assets (new commitments)	-90.41	- 93	
+ Δ Deposits (new flows)	3,000	2,000	
- Δ Accrued interest receivable	- 0.44	- 0.44	
+ Δ Accrued interest payable	0.74	0.74	
+ Δ Float	- 0.82	0.83	
+ Marketable assets	12,000		
Net cash flows	-1,024.62	- 21,57	
Cumulative net cash flows	-1,024.62	- 1,046,19	

Table Seven: Liquidity Profile

Source: author's example

If the cumulative cash flow is positive, there is no liquidity problem. If it is negative, the bank will be forced to borrow on the interbank market or at the discount window of the central bank. To avoid a market disruption with the bank coming with too large a call for liquidity, central banks have put caps on the size of the cumulative cash outflows. For instance, the Financial Services Authority (FSA) in the United Kingdom requires all banks to report all cash flows on the maturity ladder for periods of up to six months. Mismatch guidelines are set for cumulative periods of up to eight days and up to one month. Typically, these would be zero and minus 5% of the deposit base, respectively.[31]

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[31]Hall (1989) and Financial Stability Review (2000).

Cash flow gaps for 'Stress' Scenario

A similar exercise is conducted, but one considers a case of a severe liquidity shock, such as a run on bank deposits or the inability of some clients to repay their loans. Under such extreme stress circumstances, a bank needs enough liquidity to survive for a few days, a period over which the banking industry or the national central bank is expected to intervene. Two historic examples of central banks'contingency liquidity plans include the plan for the century date change, *Y2K,* (Drossos and Hilton, 2000) and the liquidity provision following the September 11, 2001 attacks on the World Trade Center and the Pentagon (McAndrews and Potter, 2002). The physical disruptions had left some banks unable to execute payments to other banks, resulting in an unexpected shortfall for other banks. To meet this liquidity problem, discount windows loans rose from about US$200 million to US$45 billion on September 12, 2001.

Section 7: Application III, Portfolio Diversification, Marginal Risk Contribution, and the Allocation of Economic Capital

In Section 5, we discussed loan pricing and introduced the concept of economic capital. Economic capital allocated to a particular loan or a business entity is the amount of equity needed to cover potential losses with some degree of confidence, such as 99.9 %. Economic capital is the capital needed to ensure the solvency of the bank in bad times. Diamond (1984) and Merton and Perold (1993) have developed a theory of bank capital based on *opaqueness* and on the desire of many customers (such as retail depositors or swaps counterparties) to deal with a very safe institution. Because the asset holdings of a bank are only disclosed with a lag and can be changed very rapidly, it is very difficult to assess the true risk of an institution. Banks will therefore face high "agency" or "information" costs in raising external capital on short notice. Therefore, a need arises to have enough capital to keep the bank solvent or, for a given amount of capital, to be well diversified. These unique characteristics of financial firms create the need for diversification of risks, a need often considered irrelevant for a corporate firm (Brealey, Meyers, and Allen 2006). The usual finance argument is that diversification of risks by firms is not necessary, as home-made diversification by shareholders will lead to the same result. The argument of Merton and Perold is that banks are *special* because information and agency costs are likely to be very high in banking, and because customers want a solvent firm with enough capital or diversification.[32] Under this argument, high solvency generates a larger clientele and franchise value. If the concept

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[32]Other authors, who have expressed a similar view, include Santomero (1995), Oldfield and Santomero (1997), and Froot and Stein (1998).

of economic capital is readily applicable to a single source of risk, it becomes more complex when one is considering a series of risks. Indeed, it is well understood that diversification is likely to reduce total risk (Markowitz, 1959) and the amount of required economic capital. We first present an application of portfolio theory to the global measurement of interest rate risk of an international bank, with interest rate exposure in four markets. We discuss next the concept of marginal risk contribution.

7.1 Aggregate Interest Rate Risk, an Example

As an illustration, we will consider the real case of an American bank running, in the late 1980s, a money market book (maturities less than a year) in four currencies: the US Dollar, the Yen, the Deutsche Mark, and the French Franc. In each book, the bank is running a mismatch position, given by the gap discussed in Section 6 (the difference between short-term assets and short-term liabilities). The currency exposure is supposed to be hedged, so that the only sources of risk are interest rate movements in the four countries. The gaps and volatilities of interest rates(σ) are reported in Table Eight. In the last column, we report the Earnings-at-Risk (EAR) for one standard deviation of interest rate.

	REPRICING GAP ($US Million)	VOLATILITY of RATES (σ)	EAR (US$ M) (Position x Volatility)
US$	gap_{US}	σ_{US}	$\lvert Gap_{US} \rvert \times \sigma_{US}$
YEN	gap_{yen}	σ_{Yen}	$\lvert Gap_{yen} \rvert \times \sigma_{Yen}$
DM	gap_{DM}	σ_{DM}	$\lvert Gap_{DM} \rvert \times \sigma_{DM}$
FFR	gap_{FFR}	σ_{FFR}	$\lvert Gap_{FFR} \rvert \times \sigma_{FFR}$
			Total Risk $= \Sigma EAR$

Table Eight: Gaps, Volatility and EAR

In 1989, this bank was measuring the total risk on its banking book with the sum of the absolute risks. However, concerned with a proper allocation of economic capital to its treasury department, and worried that central banks would use this measure of risk to calculate the capital required for interest rate risk, the bank started to apply modern portfolio theory to take into account the

diversification of risks.[33]

To apply portfolio theory, one additional piece of information is needed: the correlation between the four interest rates.

Correlation (ρ)	US$	YEN	DM	FFR
US$	$\rho_{US,US}$			
YEN	$\rho_{Yen, US}$	$\rho_{Yen, Yen}$		
DM	$\rho_{DM,US}$	$\rho_{DM,Yen}$	$\rho_{DM,,DM}$	
FFR	$\rho_{FFR,US}$	$\rho_{FFR,Yen}$	$\rho_{FFR,DM}$	$\rho_{FFR,FFR}$

The calculations of variance and standard deviation of total interest rate risk follow :

$$VARIANCE_{Total\ Risk} = (gap_{US}\ \Delta R_{US} + gap_{YEN}\ \Delta R_{YEN} + gap_{DM}\ \Delta R_{DM} + gap_{FFR}\ \Delta R_{FFR})$$

$$= \sigma^2_{Total\ risk} = gap_{US}^2\ \sigma_{US}^2 + gap_{YEN}^2\ \sigma_{YEN}^2 + gap_{DM}^2\ \sigma_{DM}^2 + gap_{FFR}^2\ \sigma_{FFR}^2$$
$$+\ 2\ gap_{US}\ gap_{YEN}\ \rho_{US,YEN}\ \sigma_{US}\ \sigma_{YEN} + 2\ gap_{US}gap_{DM}\ \rho_{US,DM}\ \sigma_{US}\ \sigma_{DM}$$
$$+\ 2\ gap_{US}\ gap_{FFR}\ \rho_{US,FFR}\ \sigma_{US}\sigma_{FFR} + 2\ gap_{YEN}gap_{DM}\ \rho_{YEN,DM}\ \sigma_{YEN}\sigma_{DM}$$
$$+\ 2\ gap_{YEN}\ gap_{FFR}\ \rho_{YEN,\ FFR}\ \sigma_{YEN}\sigma_{FFR} + 2\ gap_{DM}\ gap_{FFR}\ \rho_{DM,FFR}\ \sigma_{DMK}\sigma_{FFR} \quad (30).$$

Total Aggregate Interest Rate Risk $= \sigma = \sqrt{Variance}$

The issue of the aggregation of risks, which takes into account diversification, was applied to the measure of total interest rate risk of a bank running a 'banking' book in four different markets. This general approach, which can be applied to any source of risk, has received a lot of attention in the trading area. Value-at-Risk (VAR) attempts to measure the risk arising from a change in the market value of a trading book (Duffie and Pan, 1997 ; Jorion, 2001). As traders face many sources of risk - such as interest rate, foreign exchange, prices of equities or commodities- a tool, VAR, was needed to measure total aggregate risk on a trading portfolio. This measure is useful for central bankers wanting to impose a capital requirement on trading risks, or for banks wanting to allocate economic capital to business units. Modern Portfolio Theory (Markowitz,

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[33]Historians will notice that it took thirty years to transfer the application of portfolio theory from the equity markets, where it was first applied, to overall market risks.

1959) and simulation-based tools are widely used by banks to measure trading risks.[34] The benefits of diversification was recognized explicitly in the BIS accord on capital requirement for trading risks (Basel Committee, 1996). This was a landmark accord as, not only were banks allowed to take into account diversification, but they could also use their own *internal* model for the measurement of risk.

7.2 Marginal Risk Contribution

The application of portfolio theory and the use of simulation models have allowed banks to measure the aggregate risk of a portfolio involving many sources of risk. The objective is to have a measure of risk which incorporates the diversification benefits of risk reduction. For financial firms with multiple businesses -such as commercial banking, investment banking and insurance (or businesses in several countries), a new issue arises as to how to measure the risk contribution of a specific business unit, that is the *marginal risk contribution*. Although one can calculate the *stand alone* risk of this business (i.e. the volatility of income or the worst potential loss), one can guess that, integrated into a multi-business firms, part of the *marginal risk* will disappear through diversification.

Let us consider a bank with three assets: *A*, *B*, and *C*. It could refer to investment in commercial banking, insurance, and investment banking, or banking businesses in three different countries. We define:

A = asset position   (*A, B, C)*
σ_A = standard deviation of return on asset *A* (*A, B, C)*
σ_P = Aggregate Risk = Standard deviation of portfolio income
$\rho_{A,B}$ = correlation between return on asset *A* and return on asset *B*
$\rho_{A,P}$ = correlation between return on asset A and return on portfolio *P*

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[34]As an illustration, in its 2001 Annual Report, J.P. Morgan Chase reports a measure for total market risk arising from both its 'banking' and 'trading' books. A total market risk of US$ 129.2 million is split as follows : VAR of US$67.4 million for the trading book, VAR of US$107.2 million for the investment portfolio and A&L activities, and a portfolio diversification risk reduction of US$ 45.4 million.

Then, the variance of profit (σ_P^2) is equal to :

$$\text{Variance of profit } (\sigma_P^2) = A^2 \text{ x } \sigma_A^2 + B^2 \text{ x } \sigma_B^2 + C^2 \text{ x } \sigma_C^2$$
$$+ 2 \text{ x } A \text{ x } B \text{ x } \rho_{A,B} \text{ x } \sigma_A \text{ x } \sigma_B$$
$$+ 2 \text{ x } A \text{ x } C \text{ x } \rho_{A,C} \text{ x } \sigma_A \text{ x } \sigma_C$$
$$+ 2 \text{ x } B \text{ x } C \text{ x } \rho_{B,C} \text{ x } \sigma_B \text{ x } \sigma_C . \tag{31}$$

The standard deviation of portfolio risk (σ_P), a measure of the aggregate risk, is equal to:

$$\text{Aggregate Risk} = \sigma_P = \sqrt{} \text{ Variance}.$$

The standard aggregate risk formula is not very tractable, because the chain of cross-products in the variance makes it difficult to analyze the specific risk contribution of each business unit. To calculate the marginal risk contribution, the standard deviation of portfolio risk (σ_P) can also be written as (see proof in AppendixD) :

$$\text{Aggregate Risk} = \sigma_P = [A \text{ x } \sigma_A \text{ x } \rho_{A,P}] + [B \text{ x } \sigma_B \text{ x } \rho_{B,P}] + [C \text{ x } \sigma_C \text{ x } \rho_{C,P}] . \tag{32}$$

This expression of the aggregate risk (σ_P) is attractive as the total risk is now the sum of three components: the risks due to businesses A, B and C.[35] The contribution of each component is the product of the *stand alone* risk (A x σ_A) multiplied by the correlation ($\rho_{A,P}$) between this business and the total bank. The concept of *marginal risk contribution* follows. For instance, the marginal risk contribution of business A is equal to :

$$\text{Marginal risk contribution of business A} = A \text{ x } \sigma_A \text{ x } \rho_{A,P} . \tag{33}$$

Some have suggested using the *marginal risk contribution* to allocate economic capital to business units, that is a measure of risk which takes into account the stand alone risk of this business and the correlation between this business and the bank. However, several authors[36] have pointed out

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[35]This decomposition of the aggregate risk into a sum of components is also referred to as DeltaVAR or DVAR (Crouhy *et al.*, 2001). This measure of risk (equation 32) meets the axiom of sub-additivity (Artzner, Delbaen, Eber and Heath,1999) which states that an adequate measure of total risk should be less or equal to the sum of each individual measure of risk.

[36]Merton and Perold (1993), Stoughton and Zechner (1999), Turnbull (2000), Perold (2001), and Rosen and Zenios (this volume).

that this approach would be misleading, because the measure of aggregate risk is not a simple addition of independent components. Indeed, one can see that the marginal change in aggregate risk (32) for an increase (decrease) of business A is not just *the marginal risk contribution* ($\Delta A \times \sigma_A \times \rho_{A,P}$), but also the change in correlation between each business and the total bank ($\rho_{A,P}$, $\rho_{B,P}$, $\rho_{C,P}$), as a change in one business will change the total bank porfolio *P*. Total risk and capital are usually not additive in the risk of each component, with the implication that the separation theorem, which allows the bank to be split into a number of value centers, breaks down. Maximization of economic profit becomes again a joint maximization problem.[37]

Section 8: Bank Regulations

In a perfect market (i.e. one with full information and free entry), financial institutions will compete and the outcome will be socially optimal. Black (1970) and Fama (1980) have developed these theories of unregulated financial markets. In Section 3, we listed four private arguments for risk management in banking: managerial risk aversion, non-linearity of taxes, costs of financial distress, and market imperfections. To justify public intervention and bank regulations, one needs to identify market failures.

With respect to banking services, two main explanations have been advanced for the existence of potential market failures : Imperfect (asymmetric) information which could prevent the proper functioning of unregulated private markets, and the potential for bank runs and the related fear of systemic crises.[38]

8.1 Imperfect (Asymmetric) Information and Investor Protection

The first and most important case of asymmetric information concerns the imperfect knowledge about the solvency of a banking firm. Depositors find it costly to evaluate the solvency of their bank. The economics literature (e.g. Kay and Vickers, 1988) recognizes that the inability of consumers to properly evaluate the quality of a product can create a market failure. When depositors are uninformed, there are fewer incentives to limit the riskiness of the assets of a

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[37]In Section 4, we identified two alternative reasons for the breakdown of the separation theorem: joint operating costs and joint demand. Here, we have an additional argument: the externality created by diversification.

[38]A complete discussion of the economics of banking regulations is available in Dermine (2000, 2003).

financial institution or its degree of financial leverage (deposit-to-equity ratio). Indeed, finance theory (Merton, 1977) has shown that, whenever depositors are not properly informed, shareholders of banks benefit from an increase in risk.[39] With perfect information, depositors would react by requesting an interest rate increase to offset the transfer going to shareholders. With imperfect (asymmetric) information, this would be difficult, and would raise a well identified and documented moral hazard problem.[40]

The economics literature has identified a first potential market failure rooted in imperfect information. It is legitimate to let countries draw up prudential regulations to protect the 'uninformed' investors.

8.2 Bank Runs and Systemic Risks

The second main source of market failure is the potential for bank runs and systemic crises. Banks are special because the financial contract that emerges -illiquid loans funded by short-term deposits- creates a potential market failure and a need for public intervention. The financial contract creates the risk that depositors run to withdraw their funds. A run can be triggered by a bad news about the value of bank assets or by any unexplained fear. In either cases, there may be a loss since illiquid assets will be sold at a discount. Moreover, a bank failure could eventually trigger a signal on the solvency of other banks, leading to a systemic crisis. Here, a distinction should be drawn between a "domino" effect and a systemic crisis.

A domino effect exists if the failure of one bank directly endangers the solvency of other banks. This risk is substantially reduced today since banks systematically measure and control their counterparty exposure through, for instance, netting arrangements. A pure case of a *systemic run* could occur if, lacking information, depositors run to withdraw their funds from a significant number of banks.

This market failure explains the establishment of safety nets and banking regulations to guarantee the stability of banking markets.

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[39]The underlying intuition is that an increase in risk (variance of asset return) allows the shareholders of a firm to reap potentially large gains, while limiting the downside risk to zero because of the limited liability nature of equity shares.

[40]The potential existence of imperfect information *per se* does not yet justify public intervention. It has to be shown that private mechanisms cannot succeed. Solutions to the imperfect information problem are threefold: information disclosure, reputation to protect the long -term value of the franchise, and the supply of risk-free deposits.

8.3 Menu of Banking Regulations

In most countries government interventions and/or regulations have taken various forms:

Limits on entry: To collect bank deposits from the public, one needs to receive the authorization (a license) from the central bank. In order to do this, a bank's management must show credentials of being 'fit and proper'. Moreover, there is often a minimum capital requirement.

Rules of conduct: The rules of conduct can concern the opening of branches, deposit and lending rates, investment ratios, liquidity regulation, capital requirement, and limits on permissible activities (such as insurance or underwriting of securities). Prudential control can limit the size of interest rate and foreign exchange exposures. In many countries, central banks have exercised pressure on banks to create an Asset & Liability Committee (ALCO), whose mission is to supervise the profitability of the bank, its control of risks, and its compliance with regulations. Finally, governance pressure has been exercised on the boards of banks to nominate a few members with the specific task of monitoring the risk management process.

As many of these regulations have been found to be ineffective and often prone to regulatory capture, banking markets have been deregulated in most countries around the world and central banks[41] have retained five major forms of control: market entry (banking license), capital regulation based on an assessment of risks, liquidity regulation, regulations on interest rate and foreign exchange risks, and public disclosure of financial information. Capital regulation has been the object of intense international debate. In 1988, the Basel Committee on Banking Supervision,

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[41]In many countries, a debate has arisen as to which institution, central bank or separate public agency, should supervise banks. This has often been the mission of the central bank on the grounds that, as the provider of liquidity, the lender-of-last-resort should have full information on banks. Moreover, as the business of banks, investment banks and insurance companies is increasingly blurred and housed in one corporate financial services group, a question has arisen on the need to merge the functional regulators. In the United Kingdom for instance, banking supervision has been transferred from the Bank of England to the FSA, the Financial Supervisory Authority. In the Netherlands, the heads of banking and insurance supervision have to co-sign their review of financial services groups.

established by central banks of twelve countries,[42] drew up a minimal equity regulation that all international banks should meet. This regulation on capital is commonly referred to as the 'Capital Adequacy ratio', the BIS ratio, or the Cooke ratio, named after the first chairman of the Basel Committee. This regulation, applied since January 1993, states that the capital ratio must exceed 8 %. A revised BIS ratio will be applicable on 1 January 2007 (Basel Committee, 2004). With regard to the control of market risks, the new capital accord, Basel 2, proposes the adoption of a combination of approaches . Under 'pillar one', a formal capital requirement will be imposed on market risks originating from the trading book. Under 'pillar two', banking supervisors will be invited to control the level of interest rate risk on the banking book. One will observe that no formal capital requirement is imposed on interest rate risk on the banking book. The reason for this is that banking regulators have been unable to agree on a unique formula to measure interest rate risk on the banking book. The sources of disagreement are related to our discussion of the control of interest risk in Section 6, that is uncertain maturity on accounts such as saving deposits, demand deposits, or consumer loans. The absence of a capital requirement on interest rate risk on the banking book is a significant shortcoming of the new capital accord as, in most countries, that source of risk is substantially larger than risk on the trading book.

Conclusion

Two models of the commercial banking firm have been presented in this chapter.   The neoclassical model and the bank separation theorem allow discussion on transfer pricing and the special issue of deposits with undefined maturities. The finance-based valuation model allows the market value of the equity of a bank to be broken down into four components: the liquidation value, the after-tax franchise value, the corporate tax penalty, and the value of the unrealized capital gains/losses. It allows discussion on risk-adjusted transfer price for loans, the pricing of loans, the creation of fair loan loss provisions, and the measurement of interest rate risk. The discussion of the marginal risk contribution shows that risks are not additive, thus providing an additional argument for the cautious use of decentralization into profit centers. Breaking up the bank, and maximizing separately the value of each part, is unlikely to be optimal. Joint maximization of market value should be the objective.

Besides a comprehensive summary of the literature on ALM in Banking, this chapter makes six

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[42]It consists of senior reprentative of bank supervisory authorities and central banks from Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, The Netherlands, Sweden, Switzerland, The United Kingdom, and the United States. The secretariate of the committee is located at the Bank for International Settlements (BIS), in Basel Switzerland.

contributions. 1) It identifies the proper transfer price that should be used to evaluate the margin on risky loans. The very much used matched-maturity interbank market rate should be replaced by the expected return on a matched-maturity corporate bonds with similar risk. 2) It provides a risk-adjusted methodology to price risky loans. 3) It shows that the fair provisioning of credit losses on loans should be based on the change in the fair market value over time. This measure is related to, but different from, the much used value of expected losses. 4) It identifies the relevant maturity of the market rate that should be used to price deposits with undefined maturities, the relevant maturity of the asset that should be used for hedging, and the relevant maturity that should be used to evaluate *ex post* the performance of a deposit gathering department. It is argued that the relevant maturity of these rates is not always the same. 5) It calls the attention to the fact that *fair value accounting* proposes the evaluation of assets and liabilities of banks on a before-tax basis, and that the correct market value of the equity of a bank will also include value for tax savings on unrealized gains on assets and liabilities. 6) Finally, this chapter offers a critical review of the approach of many banks which control the impact of interest rate on accounting profit, when a sounder measure of risk should be the impact of interest rate on economic profit.

Appendix A : The relevant maturity of the transfer price.

It is argued that the choice of the relevant maturity for the transfer-benchmark rate depends on each specific application: pricing the product, selecting the hedge instrument, or evaluating *ex post* a branch performance. Let us consider the case of deposit collection, a representative case. Similar reasoning can apply to retail loans.

1. Maturity of the transfer price for pricing.
It was argued in Section 4, that, although the maturity of a deposit could be quite short, a lag in the supply of deposit and/or interest rate rigidity would require using, as a transfer price, some average of the current and forward market rates. Therefore, with regard to pricing, the choice of a longer term benchmark rate has to be justified either by a lag or by interest rate "stickiness".

2. Effective duration of deposits.
In Section 6, we showed that the effective duration of a deposit would be longer than the contractual maturity whenever an increase in the interest rate increased the value of the franchise on deposits. In this case, it is imperfectly-competitive markets (the source of the interest margin and the franchise value) that drives the choice of the appropriate duration of the hedge instrument. A simple example is the case of demand deposits with very low or no interest. As one observes that the franchise on these deposits is usually much higher in countries with high interest rates, the duration of demand deposits is much longer than the contractual short-term maturity. It must be noticed that the maturity used for pricing could differ from the maturity used for hedging. Indeed, if repricing occurs frequently and if there is no lag, the duration applicable for *pricing* should be close to the maturity of the product. However, the duration used for *hedging* could be much longer, if the franchise value increases with the level of interest rate.

3. Transfer price for *ex post* evaluation of performance
A golden rule in management accounting to evaluate a value center is to choose a transfer price that leads to value creation decisions. Based on Section 4, a branch should be given as transfer price for deposits (or loans) the relevant market rate used for pricing (i.e. an average of current and forward rates whenever there are lags or rigid rates). The transfer price must reflect the marginal profit of new business. However, the use of the current rate (or average of current and forward rates) implies that a low interest rate environment will often lead to very low performance for a branch collecting retail deposits. The reason for this is that interest margins on deposits are usually much lower in a low interest rate environment. It would be somewhat unfair to penalize the branch manager for low performance, especially when the bank, as a whole, can

be hedged with the purchase of longer duration assets and capital gains created in a declining rate environment. In short : in a declining interest rate environment, who should get the benefits of the hedge ? The retail branch or the bank? Although a formula could be devised to return the benefits of the hedge to the branch, we take the view the the value center system should reflect the true current marginal profitability based on the current rate (ignoring the benefits of the hedge). The implication is that the profitability of a deposit-gathering branch is likely to be correlated with the level of interest rates. In our view, branch performance should be evaluated vis-à-vis a 'benchmark performance level', not in absolute terms. In a low interest rate environment, one should adjust the benchmark level of performance downward to recognize that 'normal benchmark' profit will be lower.

Appendix B : Bank valuation, no tax-no growth

We show that a two-period asset A with a historical return a, a current (one-period) return a* and a discount rate of b* is equal to :

$$MV = \frac{aA}{1+b^*} + \frac{(1+a)A}{(1+b^*)^2}$$

$$= A_1^* + \left[\frac{(a^*-b^*) \times A_1^*}{1+b^*} + \frac{(a^*-b^*) \times A_2^*}{(1+b^*)^2} \right]$$

with

$$A_1^* = \frac{aA}{(1+a^*)} + \frac{(1+a)A}{(1+a^*)^2}$$

$$A_2^* = \frac{(1+a)A}{(1+a^*)}$$

The analysis can be repeated for loans, bonds and deposits to obtain the valuation formula.

Proof :

$$MV = \frac{aA}{1+b^*} + \frac{(1+a)A}{(1+b^*)^2} = \left(\frac{aA}{1+a^*} + \left(\frac{aA}{1+b^*} - \frac{aA}{1+a^*} \right) \right)$$

$$+ \left(\frac{(1+a)A}{(1+a^*)^2} + \left(\frac{(1+a)A}{(1+b^*)^2} - \frac{(1+a)A}{(1+a^*)^2} \right) \right)$$

$$= \left(\frac{aA}{(1+a^*)} + \frac{(1+aA)}{(1+a^*)^2} \right) + \left(\frac{aA(a^*-b^*)}{(1+a^*)(1+b^*)} + \frac{(1+a)A(a^*-b^*)((1+a^*)+(1+b^*))}{(1+a^*)^2(1+b^*)^2} \right)$$

$$= A_1^* + \frac{(a^*-b^*)\left(\frac{aA}{1+a^*} + \frac{(1+a)A}{(1+a^*)^2} \right)}{(1+b^*)} + \frac{(a^*-b^*)\frac{(1+a)A}{1+a^*}}{(1+b^*)^2}$$

$$= A_1^* + \left[\frac{(a^*-b^*) \times A_1^*}{1+b^*} + \frac{(a^*-b^*) \times A_2^*}{(1+b^*)^2} \right]$$

Appendix C : Bank valuation, the corporate tax case

We show that the after-tax value of a two-period asset A issued at par with historical return a, current (one period) return a^*, and discount rate b^* is equal to :

$$MV = \frac{(1-t)aA}{(1+b^*)} + \frac{(1-t)aA + A}{(1+b^*)^2}$$

$$= A_1^* + \left[\frac{(a^* - b^*) \times A_1^*}{1+b^*} + \frac{(a^* - b^*) \times A_2^*}{(1+b^*)^2} \right]$$

$$+ \left[-\frac{t b^* A_1^*}{1+b^*} - \frac{t b^* A_2^*}{(1+b^*)^2} \right]$$

$$+ \left[\frac{t(A_2^* - A_1^*)}{1+b^*} + \frac{t(A_3^* - A_2^*)}{(1+b^*)^2} \right]$$

where

$$A_1^* = \frac{aA}{(1+a^*)} + \frac{(1+a)A}{(1+a^*)^2}$$

$$A_2^* = \frac{(1+a)A}{(1+a^*)}$$

$$A_3^* = A$$

Proof :

$$MV = \left[\frac{aA - t(aA + A_2^* - A_1^*)}{1+b^*} + \frac{(1+a)A - t(aA + A_3^* - A_2^*)}{(1+b^*)^2} \right]$$

$$+ \left[\frac{t(A_2^* - A_1^*)}{1+b^*} + \frac{t(A_3^* - A_2^*)}{(1+b^*)^2} \right]$$

denoting by T the last factor (the capital gain tax shelter), we have :

$$MV = \frac{aA - t(aA + A_2^* - A_1^*)}{1 + a^*(1-t)} + \frac{(1+aA) - t(aA + A_3^* - A_2^*)}{(1+a^*(1-t))^2}$$

$$+ \left[\frac{aA - ta^*A_1^*}{1+b^*} - \frac{aA - ta^*A_1^{*1}}{1+a^*(1-t)} \right]$$

$$+ \left[\frac{(1+a)A - ta^*A_2^*}{(1+b^*)^2} - \frac{(1+a)A - ta^*A_2^*}{(1+a^*(1-t))^2} \right] + T$$

The Tax Invariance Theorem of Samuelson (1964) allows us to write :

$$MV = A_1^*$$

$$+ \left[\frac{(aA - ta^*A_1^*)(a^*(1-t) - b^*)}{(1+b^*)(1+a^*(1-t))} + \frac{((1+a)A - ta^*A_2^*)(a^*(1-t) - b^*)((1+a^*(1-t)) + (1+b^*))}{(1+b^*)^2(1+a^*(1-t))^2} \right]$$

$$+ T$$

$$= A_1^* + (a^*(1-t) - b^*) \left(\frac{\dfrac{aA - ta^*A_1^*}{1+a^*(1-t)} + \dfrac{(1+a)A - ta^*A_2^*}{1+a^*(1-t)^2}}{1+b^*} \right)$$

$$+ \frac{\dfrac{(1+a)A - ta^*A_2^*}{1+a^*(1-t)}}{(1+b^*)^2} + T$$

$$MV = A_1^* + \left[\frac{(a^* - b^*)xA_1^*}{1+b^*} + \frac{(a^* - b^*)xA_2^*}{(1+b^*)^2} \right] + \left[-\frac{tb^*A_1^*}{1+b^*} - \frac{tb^*A_2^*}{(1+b^*)^2} \right]$$

$$+ \left[\frac{t(A_2^* - A_1^*)}{1+b^*} + \frac{t(A_3^* - A_2^*)}{(1+b^*)^2} \right]$$

This analysis can be repeated for loans, bonds and deposits to obtain the valuation formula.

Appendix D : Proof of marginal contribution formula

$$\sigma_p^2 = \sum_i \sum_j x_i x_j \, \text{Cov}(R_i, R_j)$$

$$= \sum_i x_i \, \text{Cov}(R_i, R_p)$$

$$= \sum_i x_i \rho_{i,p} \, \sigma_i \sigma_p$$

$$\sigma_p = \sum_i x_i \, \sigma_i \rho_{i,p} \, .$$

Most often, available correlations concern those between between pairs of businesses. As the above formula demands the correlation between each business and the portfolio, here are the formulae to move from pairwise correlations to those between one business and the portfolio.

We define:

Asset position : A, B, C

σ_A = Standard deviation of return R_A on asset A (*B, C*)

P = Portfolio Income = A x R_A + B x R_B + C x R_C

σ_P = Standard deviation of portfolio income

$\rho_{A,B}$ = correlation between return on asset A return and return on asset B

$\rho_{A,P}$ = correlation between return on asset A return and income on portfolio P

$\rho_{A,P}$ = Covariance (R_A, Portfolio Income) / (σ_A x σ_P)

with Covariance (R_A, Portfolio Income   ) = Covariance (R_A, AR_A + BR_B + CR_C)

$$= A \text{ Covariance } (R_A, R_A)$$
$$+ B \text{ Covariance } (R_A, R_B)$$
$$+ C \text{ Covariance } (R_A, R_C)$$
$$= \quad A \times \sigma_A \times \sigma_A$$
$$+ B \times \rho_{A,B} \times \sigma_A \times \sigma_B$$
$$+ C \times \rho_{A,C} \times \sigma_A \times \sigma_C$$

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