Financial Risk Management -Theory and Practice

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1. Introduction

- Financial risk management is the activity of monitoring financial risks and managing their impact.
  - It is a sub-discipline of the wider task of managing risk, that is, controlling the effects of uncertain and generally adverse external developments (or events) on the firm's activities or projects.
  - It is a practical application of modern finance theories, models and methods.

What is Risk?

- Risk is the chance (or probability) of a deviation from an anticipated outcome.
  - It is not limited to consideration of losses, but looks at the extent and probability of all of the deviations.
  - It is a function of objectives. Without an objective or intended outcome, there is only uncertainty.

Risk Stratification

- Bryan Wynne (1992) proposed a four level stratification:
  1. Risk: where probabilities are known
  2. Uncertainty: where the main parameters are known, but quantification is suspect
  3. Indeterminacy: where the causation or risk interactions are unknown
  4. Ignorance: risks have escaped detection or have not manifested themselves

Risk can be quantified; whereas uncertainty cannot.

Risk Management Approach

- If we use the term risk factor to refer to a particular risk, then the total risk will be made up of one or more risk factors.
  - A risk profile is a graphical representation of the payoffs associated with changes in the risk factor.
  - Rather than focusing on risk elimination, the firm typically considers the trade-off between risk taken and the expectation of reward.
  - Liquidity risk arises when there may not be a counterparty willing to transact at a price close to the previously recorded transaction, within a reasonable time.

Strategic Impact of Price Volatility

- The currencies in which a firm earns its revenues or incurs its production costs have a direct impact on their competitiveness and profitability, even if they participate only in domestic markets.
- Volatility in interest rates may mean that a company increases the hurdle rate on an investment or a requires faster payback.
- The oil price shocks demonstrate the same factor in commodity markets.

Risk Management Objectives

- Two criteria typically predominate decisions:
  - The costs of reducing risks
  - Setting risks at an acceptable level
  - When there is an actual or prospective major loss, the focus shifts to stability or even survival.
- Firms will want to arrive at an acceptable level of exposure in order to allow managers to focus on the core activity of value creation, and not be preoccupied with the nature, extent and consequences of risks in the business.

Steps to Risk Identification

- Awareness: (1) risks that are unknown, (2) risks that are known but not measurable, and (3) risks that are known and measurable.
- Measurement: the task is to model the risk in order to measure its impact, thus allowing decisions to be made on a course of action.
- Adjustment: changing the nature, probability or impact of the risk. These include behavior change, insurance (transfer), operational hedging and financial hedging.

2. Management of the Firm

- A firm may be risk averse, be risk neutral or be a risk taker (seeker).
  - As a general rule, firms will be risk takers in areas where they have some comparative advantage, but seek to hedge or eliminate risks where they do not.
  - Most firms will manage core business risks internally.
  - They may seek to reduce exposures to changes in economic variables (like interest rates, inflation, currencies and commodity prices) through operational and financial hedging.

Hedging Strategy

- Altering operational procedures as a risk management tool can be costly and firms are generally disinclined to use this (operational or ‘strategic’ risk management) as their primary means of controlling market exposures.
- Firms resort to financial hedging:
  - Does not disturb existing business relationships.
  - They are quick to implement.
  - Transaction costs are quite low.
  - The hedge can be cheaply reversed if no longer appropriate (assuming liquidity).

Factor Analysis

- The initial stage of risk analysis will seek to determine both direction of the slope and its sensitivity (gradient) to changes in the risk factor.
- Some of these will have offsets, albeit inexact ones, within the firm's portfolio (assets, liabilities, contracts, projects etc.). A key risk management task is to identify the net effects of the different factors.
- For transaction risks, this is fairly straightforward. This is more problematic for economic risks (market environment, government, competition) and may well require strategic decisions by the firm.

Why Manage Risk?

- Risk management should increase the expected value of the firm: the present value of the future *expected* cash flows generated by its operations.
  - By changing the expected cash flows, or
  - By reducing the volatility of cash flows (i.e., risk), and thereby reducing the returns required by investors.
- An attempt to manage the unsystematic element of the risk (one that can be diversified away at the shareholder portfolio level) is, at best, redundant and, at worst, wasteful.

Taxes

- The ability to create a ‘tax shield’ provides a real incentive for firms to manage their expected cash flows in such a way as to postpone tax liabilities.
- If the firm faces progressive tax rates, reducing the variability of expected profits will reduce taxes. The more convex the tax function and the more volatile the firm’s expected income, the greater the tax benefits.

Agency Costs

- Agency costs arise because the interests of the owners (principals) diverge from those of the agent(s), and it is costly to ensure that the agent always acts in the best interest of the principal.
  - Such problems lead to principals putting controls or restrictions on the activities of their agents.
  - Such controls include requirements such as audits, formal reviews, limits to authority and so on.
  - Interests might be aligned through incentive schemes such as profit-sharing or performance related bonuses.

Debt and Equity Claims

- It is possible to see debt holders as having written a put option with the shareholders on the future value of the firm.
- In a situation where the firm can engage in two different projects, both with the same cost and with the same expected return, but with one having a higher dispersion of outcomes, the higher-risk project provides shareholders with a higher expected return since the debt holders will bear some of the loss in adversity.
  - However, the same variance in cash flows might be seen by outsiders as reducing a firm's credit quality.

Financial Distress

- Financial distress is a situation where a firm has difficulty meeting its fixed-claim liabilities. (If it were unable, it is bankrupt – not distressed.)
  - This is most costly in cases where the company uses firm-specific assets and makes specific investments that cannot be fully recovered if the firm ceases to trade.
  - Research suggests that the direct costs may be far less than the indirect costs: loss of sales (especially where warranties or service contracts may be in doubt), management time, loss of employees, inability to maintain or replace assets.
  - Hedging reduces the variance of future expected cash flows, and thus reduces the probability of distress.

Drivers of Risk Appetite

- Appetite for volatility of equity value (ill-diversified investors)
- Threat of bankruptcy or restructuring costs
- Higher probability of financial distress
- Management preference
- Actual or potential conflicts between classes of security (notably shareholders and debt holders when there is high gearing)
- Volatility of underlying cash flow
- Tax effects
- Ability to invest in positive NPV projects

3. Market Mechanisms & Efficiency

- Capital markets bring together borrowers and lenders:
  - Equity claims (stock market)
  - Short-term debt claims (money market)
  - Long-term debt claims (bond market)
- Foreign exchange markets bring together buyers and sellers of currencies
- Commodities markets bring together producers and consumers.

Financial Risks

- Liquidity risks are mitigated by financial intermediation, where middlemen are prepared to buy or sell with the intention reselling or repurchasing.
- If the transaction intends to create an offset to a present holding (i.e., the matching principle), then timing risk is critical. The possible migration of prices before a transaction can be completed is the execution risk.
- Credit risk can take two forms: default risk (the failure of the counterparty to perform) and downgrade risk (a lowered market valuation of that firm's general ability to perform).
- Settlement risk: delays in transfer of documents or of payment (an element of credit risk)

Non-financial Risks

- Legal risk: enforceability of a contract
- Regulatory risk: governmental impairment of market efficiency, often through increased transaction costs
- Accounting or tax risk: usually based on receiving favorable accounting or tax treatment

These risks will have a financial impact, but it is unrelated to underlying price movement.

Efficiency

- The ability and speed with which markets react to news is an indication of their efficiency.
- If short-term price movements could be predicted on the basis of price patterns or other market indications, they would be acted upon by all participants. Thus, movements become effectively random. Longer-term prices can be related to variables such as economic growth.
  - The Efficient Markets Hypothesis does not suggest that price randomness is senseless; rather, it is the result of competition among rational investors seeking superior returns.

Efficiency, 2

- EMH postulates three levels:
  - Weak-form: participants cannot make abnormal returns by analyzing previous price behavior
  - Semi-strong form: extends the weak form to include publicly-available information
  - Strong-form: extends semi-strong form to include all information, whether available publicly or not
- A market is transparent when it is possible to observe the behavior of other participants.
- The extent to which the market incorporates new information to generate asset prices bears upon the value of those prices for decision-making.

Methods of Intermediation

- Acceptance: carrying out a transaction for a client and also guaranteeing that the client will perform under the terms of the agreement, as where a bank guarantees a documentary credit.
- Broking: acting as an agent to find the other side for a transaction.
- Dealing (market making): being willing to act as a buyer or seller, according to the need of the client.

Bid – Offer Spread

- There are four elements that determine the bid – offer spread:
  - The cost of being in business
  - The cost of assuming risk: volatility, capital commitment
  - The cost of being wrong
  - The degree of competition among market makers
- We expect a negative relationship between turnover and spreads in individual securities.

Systematic and Non-Systematic Risk

- Financial theory calls the tendency of assets to show similar behavior systematic risk, and the individual differences specific (or non-systematic) risk. An asset will have both elements.
  - Assets will not all be affected to the same extent by systematic risk.
  - Diversification has the effect of eliminating the specific risk element, since the gain in one asset from idiosyncratic factors is compensated by losses on another asset from other specific factors.

Capital Asset Pricing Model

- The return on an asset will be a linear function of the degree to which the asset has systematic (market) risk:
  - $E(r_a) = r_f + \beta_a(E(r_m) - r_f) + \varepsilon_a$ where $E(r_a)$ is the expected return on the asset, r_f is the risk-free rate, $E(r_m)$ is the expected return on the market factor, β_a is the asset's beta, or risk relative to the market factor and ε_a is the specific risk (with expected value of zero, i.e., is unpriced here).
- The beta of an asset is a function of the covariance of the return on the asset and the market factor divided by the variance of the market return:
  - $\beta_a = \text{Covariance}_{a,m} / \text{Variance}_m = (\rho_{a,m}\sigma_a\sigma_m)/ \sigma^2_m$

Credit Risk

- The difference in valuation after pricing in the expected cost of default is expressed in terms of a difference in the interest rates used to present value the cash flows, that is, a credit spread.
  - This is a risk-neutral formulation. Typically, there is a further discount representing a pure risk premium.
  - The spread will be driven by the counterparty's perceived creditworthiness, the term of the asset, the expected liquidity of the issue, tax effects and any special rights or conditions.
  - A stream of payments will be discounted by a weighted-average for the term.

4. Interest Rate Risk

- The value of rate-sensitive assets depends directly or indirectly on the interest rate (or the discount rate) used to present-value the cash flows.
- Interest rate risk is the risk arising from changes in the rate of interest of borrowed or invested (including lent) money.

Sources of Interest Rate Risk

- Price Risk the interest rate used to give the present value of future cash flows.
  - Bond price = $C\,[(1 + i)^t - 1] / i(1 + i)^t + 100/(1 + i)^t$ where C is the coupon, i is the prevailing interest rate and t is the maturity of the bond.
  - Asset prices fall when interest rates rise and *vice versa*.
  - Sensitivity increases with maturity.
  - Zero coupon bonds ("strips") have the highest sensitivity to a rate change, since all of the value is reflected in the terminal cash flow.

Sources of Interest Rate Risk, 2

- Reinvestment Risk the interest rate used to give the future value of, or compound, cash flows into the future.
  - The risk arises when maturing cash flows (e.g., coupons or payments) need to be recycled into new investments or new borrowings.
  - The future value of reinvested cash flows increases as interest rates increase.

Sources of Interest Rate Risk, 3

- Prepayment Risk (sometimes known as call risk) arises if the borrower has the right to repay the debt prior to contract maturity.
  - The opportunity arises for the borrower if he can refinance at lower rates. Thus, the risk rises as the rates fall.
  - If the option is in the money, the value of the future cash flow is capped at the present value of the coupon plus the penalty for exercising the call.

Sources of Interest Rate Risk, 4

- Extension Risk arises when the borrower has an (yet unexercised) option to modify the cash flows.
  - In a mortgage-backed security, for example, where repayment of interest and principal are supported by mortgages on property, the borrower often has an option to prepay, sometimes subject to a penalty. For a portfolio of such assets, there is going to be an expected number of such payments, but the actual number may be more or fewer.
  - Extension does not refer to a lengthening of the term in the same way that prepayment shortens it. Rather, the expected number of prepayments is less, thus effectively "extending" the expected term.

Term Structure

- The term structure of interest rates is often shown graphically in what is known as a yield curve.
  - The observed shape and form is not stationary over time – the curve changes in response to new information and the changing views of market participants.
  - There is the classic upward slope, implying a premium (contango); a downward slope, implying discount (backwardation); flat; or humped.

Traditional Term Structure Theories

1. The Expectations Theory proposes that the shape of the yield curve is determined by market participants' view on the future course of short-term interest rates and the demand for securities of a particular maturity.
   - The theory states that the expected return on a security of whatever maturity is the same for the same holding period. That is, investors expect to earn the same return from holding a two-year security for one year as would be obtainable from holding a one-year security for one year.
   - $(1 + {}_0r_n) = [(1 + {}_0r_1)\,(1 + E_0({}_1r_2))\,(1 + E_0({}_2r_3) \ldots (1 + E_0({}_{n-1}r_n)\,]^{1/n}$

Traditional Term Structure Theories

1. Expectations Theory, cont.
   - Long-term interest rates are determined by short-term interest rates and the degree to which short-term rates are correlated across time.
2. The Liquidity Preference Theory proposes that investors require a maturity risk premium as compensation for holding longer maturity investments.
   - The liquidity premiums over the expected rates would be increasing, but the underlying expected rates are not necessarily increasing (could be flat or humped).

Traditional Term Structure Theories

2. Liquidity Preference Theory, cont.
   - Under this theory, the short-term rates derived from the yield curve will overstate the short-term rate when the curve is upward sloping, and understate when the curve is inverted.
3. The Market Segmentation Theory proposes that market participants have a preferred maturity range in which they like to borrow or lend.
   - The yield curve is therefore a series of maturity-segmented markets.
   - If these preferences are tied to underlying assets or liabilities, the participants will be less and less willing to substitute as they move away from their preferred range ("habitat").

A Modern Term Structure Theory

- Changes in short-term interest rates are characterized by two components:
  - The first is a deterministic process that brings the rate back to its central tendency at a given rate per period.
  - The second is a random variable taken from a normal distribution with a mean of zero and a standard deviation of one.
  - The deterministic component is required to account for the observed ‘mean reversion’ of interest rates; the stochastic element provides for the unpredictable changes in rates.

Analyzing the Yield Curve

- The spot rates or zero-coupon rates derived from the yield curve provide the interest rates for valuing future cash flows.
- The nominal interest rate can be decomposed into two elements: a real interest rate and an inflation premium.
  - $(1 + r_{\textbf{nominal}}) = (1 + r_{\textbf{real}}) \times (1 + \text{expected inflation})$
  - If investors expect to earn a real rate of 4 percent and inflation is anticipated to be 3 percent, then we would expect a nominal rate = (1.04) x (1.03) = 7.12%

Analyzing the Yield Curve, 2

- We can characterize the change in shape of the yield curve, as expectations about inflation change, as a parallel shift (all maturities change by the same amount) or as a rotational shift (yield curve pivots around a particular maturity point).
- Both shifts can occur simultaneously, leading to twisting effects.

The Money Markets

- … are short-term markets (usually one year or less) for loan instruments made between borrowers and lenders.
  - Examples include bank deposits, interbank loans, commercial paper, certificates of deposit, bankers' acceptances, bills of exchange, promissory notes and documentary credits.
  - They normally have just two cash flows: an initial investment/ receipt (PV) followed by the later repayment of the principal and interest (FV).

Term Instruments

- Most debt instruments with maturities longer than one year – such as term loans, bonds or notes – have multiple cash flows.
  - The borrower agrees to pay a fixed or variable interest payment (a coupon) for a specific period and a final payment of interest together with the principal borrowed.
  - With an annuity structure, from the first periodic payment, principal is being return to the lender.
  - With a balloon arrangement, the an interim principal payment is deferred to some time before maturity.
  - A bullet maturity means that all the principal is repaid at the end.

Bond Calculations

- Bond returns are normally expressed in terms of the security's internal rate of return or yield. With no option for early redemption:
  - $PV = C_1/(1+y)^1 + C_2/(1+y)^2 + \ldots + C_m/(1+y)^m + P/(1+y)^m$ where C is the coupon payment, P is the principal and y is the constant discount rate used to relate the present value (PV) or market price of the bond to its future cash flows.
  - The formula can be used to price a bond between payment dates – producing a full or "dirty" price – that is reflective of the interest accrued but unpaid. We can then make an adjustment for accrued interest to get a market or "clean" price.

5. Currency Risk

- Foreign exchange rate risk can arise from changes in the spot rate and changes in the forward rate. The latter is a complex risk since it combines changes in the spot rate with changes in the relative interest rates between the two currencies.
- The value, or exchange rate, of one currency in relation to another changes over time in response to market forces.

Other Risk Factors

- The exchange rate is also influenced by economic and political conditions:
  - Differences in inflation rates and interest rates between countries
  - Policies being pursued by the government: controls on imports, transfer risk, country risk (expropriation)
  - Political stability of the government and country

Explanatory Models

1. Interest Rate Parity
2. Purchasing Power Parity
3. Expectations Theory
4. International Fisher Effect

Interest Rate Parity Model (IRP)

- IRP: the forward price or exchange rate ($F_{D/F}$) at time (t) between the domestic (D) and the foreign currency (F) will be equal to the interest rate differential between the currencies:

$$\frac{1+r_{F(t)}}{1+r_{D(t)}} = \frac{F_{D/F(t)}}{S_{D/F}}$$

- If the spot exchange rate = USD 1.50/£, and the USD interest rate is 6% and the sterling rate is 8%, then: 1.5 x (1.06/1.08) = 1.4722. If interest rates were flat, the two year forward: 1.5 x ($1.06^2/1.08^2$) = 1.4450.

Covered Interest Arbitrage

Spot = USD 1.50/£ implying 1 year forward = 1.4722

- If one year forward = USD 1.45/£
- Borrow £ @ 8%
- Buy USD @ spot
- Invest @ 6% = 1.59
- Sell forward @ 1.45 = £ 1.0966
- Borrowing cost = 1.08
- CIA = £ 0.0166

- If one year forward = USD 1.49/£
- Borrow USD @ 6%
- Buy £ @ spot
- Invest @ 8% = 1.08
- Sell forward @ 1.49 = USD 1.6092
- Borrowing cost = 1.59
- CIA = USD 0.0192

Purchasing Power Parity

- Absolute purchasing power parity: if a product is manufactured in two countries, then under the law of one price, it should have the same value in both markets.
  - Otherwise, one could purchase it in the cheaper location and ship it to the other for a riskless profit.
- Relative purchasing power parity: compared to a period when rates are in equilibrium, changes in the differential inflation rates will be offset by equal but opposite changes in the forward rate.

Expectations Theory

- The forward rate should reflect participants' expectations of what the future spot rate is likely to be.
  - Otherwise they will be willing to buy or sell to capture the value in "mispriced" rates until equilibrium is established.
- The average forward rate is an unbiased estimate of the future spot rate.
  - There is, however, considerable variability between the forward rate and the actual future spot rate.

International Fisher Effect

- This is an extension of Irwin Fisher's analysis that lenders seek a nominal interest rate that compensates them for the effects of inflation and also allows them to earn a real rate of interest.
  - In the absence of controls, capital will flow to the country with the higher real rates until the returns are equalized.
  - Therefore, differences in observed rates must arise from differences in expected inflation.

Fisher Effect, mathematically

$$\frac{1+r_{F(t)}}{1+r_{D(t)}} = \frac{E(1+i_{F(t)})}{E(1+i_{D(t)})}$$

Ratio of nominal interest rates is equal to the ratio of <u>expected rates of inflation</u>

$$\frac{S_{F(t)} - S_F}{S_F} = \frac{r_{F(t)} - r_{D(t)}}{1+r_{D(t)}}$$

Proportional change in spot rate is equal to the proportional change in nominal rates

Foreign Exchange Exposure

- Various risks will affect an organization's reported accounting numbers.
  - Transaction exposure is where the value of contract payables or receivables are in a foreign currency, and vary directly with the exchange rate until paid.
  - Translation exposure is not directly related to cash transactions, but arises from the conversion of foreign currency items (e.g., a fixed asset located in a foreign jurisdiction) to the reporting currency.
  - A firm will have long (positive) exposure if exposed assets > exposed liabilities, and short (negative) exposure if exposed assets < exposed liabilities.

Foreign Exchange Exposure, 2

- Economic: effect of a significant deviation from purchasing power parity, thus affecting the value of future cash flows.
  - Direct exposures are those where the changes in exchange directly affect the firm.
  - Indirect exposure is the impact of changes in the exchange rate upon competitors and suppliers, and their competitors and suppliers, etc.

Sensitivity to Economic Exposure

1. Local firm: Costs and revenues are denominated in the local currency. Sensitivity is low.
2. Exporter: Costs are in local currency but revenues are in foreign currencies. Sensitivity is high.
3. Importer: Costs are in foreign currencies but revenues are in local currency. Sensitivity is high.
4. Global firm: Costs and revenues are denominated in foreign currencies. Sensitivity is low.

6. Equity & Commodity Price Risk

- Equity is the risk-taking element in a firm's capital structure. It provides a real claim on the underlying cash flows.
  - Once all debt claims are satisfied, the residual claim to the firm and its cash flows accrues to equity holders.
- The simple cash flow model suggests two potential sources of equity risk, one of which will be systematic – that is, general to all firms – and the other firm-specific.

Sources of Equity Risk

- The rate of return that investors seek will be related to:
  - The risk-free rate, and expected changes in that rate.
  - The risks attached to future cash flows. The systematic portion (beta) is measured by the covariance of returns divided by the variance of market returns, and changes only very slowly. The firm-specific risk is related to their own performance within their markets and sectors, or the impact of particular events.

Attributes of Common Shares

- Holders of common (ordinary) shares have *pro rata*:
  - Right to dividends
  - Share of residual value on winding up
  - Limited access to the company's financial records and accounts
  - Voting privileges
  - For listed companies, the right to freely transfer ownership
  - In some jurisdictions, subscription privileges (to maintain share of ownership)
  - Liability limited to the investment represented by the share

Commodities

- … is a generic term for traded raw materials.
  - Hard commodities are non-perishable. The class is divided into precious metals and base metals. “Softs” include the agricultural products. Energy commodities include crude oil, natural gas and refined products.
- In contrast with financial assets:
  - There are significant costs associated with holding or delivering a commodity.
  - There may be wide price fluctuations produced by a perceived surplus or shortage.
  - As there is limited scope for substitution, there is a convenience yield associated with holding the commodity.

7. Behavior of Asset Prices

- The returns from holding financial assets largely conform to a normal distribution (a log-normal distribution), except:
  - There is a higher incidence of more extreme price changes, with the ‘fat tails’ called leptokurtosis.
  - There is a higher incidence of small price changes, with the higher peak (mode) called kurtosis.
  - There is negative skew, i.e., more observations to the left of the mean.
- Price changes are essentially random, akin to geometric Brownian motion (GBM). The likelihood of a large migration in prices increases with time.

Calculating Price Changes

- The conversion of the price relative (P_t / P_{t-1}) to a natural logarithm (to the base $e = 2.71828$) allows the use of addition and subtraction and other standard statistical techniques.
- As we shorten the interest frequency, the effective rate goes up (likewise, the equivalent rate goes down).
  - The highest interest rate is provided by continuous compounding or, as it is sometimes known, the force of interest. This is virtually equivalent to daily compounding.
  - The term e^{rt} provides the continuously compounded rate of return on an asset.
  - The term e^{-rt} provides continuous discounting.

Converting Interest Frequencies

- To convert from a higher frequency pay to an annual equivalent:
  - $r_{\textbf{effective}} = [\ 1 + (r_{\textbf{nominal}} / f)^{f}\ ] - 1$ where f is the annual frequency
  - 5% paid semi-annually = $1 + (.05 / 2)]^{2} - 1 = 5.0625\%$
- To convert from a lower to higher frequency payment:
  - $r_{\textbf{annual}} = [\ (\ 1 + r_{\textbf{effective}}\ )^{1/f} - 1\ ]\ x\ f$
  - The quarterly equivalent of a 5% annual pay $= (\ 1 + .05)^{0.25} - 1\ ]\ x\ 4 = 4.9089\%$

Continuous v. Discrete Distribution

- One advantage of converting price changes to a continuous process is that continuous probability distributions can be used to estimate the likelihood that a return (and hence the future price) will fall within a given parameter.
  - Such a distribution is readily available for variables given the log transformation and is known as the lognormal distribution.
  - From a conceptual perspective, this provides a measure of the continuous rate of change in the asset price. By converting a weekly or monthly price relative into continuous returns, we effectively obtain a series of one-day (or other period) returns.

Volatility

- …is the term that is commonly applied to the measure of price or rate dispersion seen in financial markets.
  - We would describe an asset with a larger dispersion (i.e., a greater range of potential outcomes) as ‘riskier’.
  - The historical record in this respect provides only a guide to the future risk. A projection based on historical volatility embeds an assumption that the future will be like the past.
- Volatility arises because market participants reassess the worth of an asset.
  - In an efficient market, the price of an asset reflects known information about the asset. As new information is received, views about the value of an asset change.

Asset Value

- There are two components driving the asset value:
  - The first is the range of values that can be assumed at the end of the period.
  - The second is the probabilities attached to this range.
  - For market participants, changes in assessments of both these factors over time will change the current value since both will have an impact on the expected asset price.
  - It is the expected distribution of price changes that give us the asset's current value.

Measuring Volatility

- Historical volatility is a measure of the dispersion of actual asset price movements in a given time period.
  - As a measure, volatility is the annualized standard deviation of the daily return.
  - This may suffer from the problem of extrapolation.
- Implied volatility is the market consensus as the the future potential distribution of outcomes that may exist over the life of an option.
  - The approach involves ‘backing out’ the volatility in observed options prices using an option pricing model.

Price-Generating Process

- Prices appear to move randomly; statisticians call such behavior stochastic.
- In a Markov process, the current price is the only useful variable for predicting the future. As in a weak-form efficient market, no other analyses enable participants to earn abnormal returns.
- A variant of Markov is a Wiener process: a change in price (r) for a given period is based on a random variable Φ drawn from a normal probability distribution with a mean of zero and a standard deviation of one. Thus:
  - $r = \Phi (\Delta t)^{1/2}$

Price-Generating Process, 2

- If asset prices move in discrete time, a geometric Brownian motion model gives a price change:
  - $\Delta P/P = \mu \Delta t + \sigma \Phi(t)^{½}$ where for a small time period (Δt), the change in asset price (ΔP) will be given by the expected return per unit (μ), a random variable (Φ) drawn from a standard normal distribution and the volatility of the asset price (σ).

Dealing with Deviations

- Although the normal distribution assumption is convenient – and essential for most risk management approaches – observed price behavior is not fully explained and can create surprises in a risk management context.
  - This has led to use of ‘stress tests’, whether created by scenarios or simulation.
  - Two alternate models are the compounded distribution – which combines two normal distributions with different standard deviations to create the kurtosis – and a jump-diffusion process – which inserts price “jumps” to the usual diffusion, thus replicating the fat tails.

8. Controlling Risk

- Risk management aims to control the amount of exposure a firm takes to one or more risk factors.
- Any form of analysis requires a reduction in the complexities of situations to more manageable proportions.
  - This reduction comes at the expense of completeness.
  - There are also possible gaps between perception and reality.

RM System

1. What are the risks the firm is taking?
   - A risk audit may provide an initial understanding of the threats.
2. Can these risks be quantified?
   - What monitoring is required?
   - What is the time frame over which the risks are to be measured?
3. What risks does the firm manage well (and should manage internally) and which should be passed to others?

RM System, cont.

4. Does the infrastructure for risk control exist?
   - Are there well thought-out Policy & Procedures?
   - Is there adequate process control?
   - Does reporting, process review and audit ask the right questions?
5. Regarding decision-making processes:
   - Is there unambiguous authority and accountability?
   - Are there clear reporting lines?
   - Can management act timely?

Risk Management Considerations

- Risk threshold: the amount of risk that the firm will tolerate over the relevant time horizon.
- Confidence limits: based on volatility and risk appetite, this may alert managers to the need to take corrective action.
- Materiality: considering the costs and benefits of devoting resources to managing the risk in question.

Controlling Risks

- The firm might change its operations to balance inflows and outflows (matching principle). Such arrangements, however, tend to impair the firm's flexibility to respond to changing circumstances.
- Financial methods might be on-balance sheet (e.g., offsetting foreign income flows by borrowing in the same currency) or off-balance sheet (e.g., commodity exposure managed with a contract for differences).
- Some firms have a greater capacity to absorb and manage certain risks. The sale of an option may facilitate such a transfer.

Risk Sensitivity

- One way of looking at risk is to measure the change in a position's value for a given change in the underlying exposure.
  - The steepness of the slope (or coefficient) indicates the sensitivity.
  - The direction (sign) indicates whether the exposure is positively or negatively related to changes in the risk.
- A top-down approach uses aggregate information to derive a residual sensitivity. A building-block approach builds up a net, group-level sensitivity by adding up (and netting off) the individual exposures.

RM Approaches

- One way of adapting accounting information is to set particular limits on various ledger entries, e.g., a counterparty credit limit.
- The can be supplemented by marking-to-market or revaluation, where the value of an asset or liability is compared to its current market price, thus indicating trading performance or giving a notional liquidation value.
- Value at Risk is a predictive method that, based on the price diffusion process, estimates the maximum potential loss over a given time horizon and confidence limit.

Prominence of VaR

- Captures the holistic effects of risk by uniting all product lines and asset segments using a common methodology.
- The methodology is generally robust.
- Has immediacy and relevance for senior management.
- Meets with the desire of regulators for enhanced disclosure of the risks within individual firms.

Elements of VaR

1. The amount of the exposure (A)
2. The volatility of the asset position (σ), usually expressed as an annual rate
3. A confidence limit α in terms of the number of standard deviations, usually $1 < \alpha < 2$
4. A time horizon T. If T < one year, the volatility is adjusted by $\sqrt{T}$

$$VaR = A \times \sigma \times \alpha \times \sqrt{T}$$

VaR Variants

- Parametric VaR: also called variance – covariance VaR, estimates volatilities and correlations between assets.
- Historical: ranks past valuations, then defines HVaR = 1 - α, where α is the confidence limit.
- Simulation: usually built from runs produced by a Monte Carlo model.
- Undiversified VaR: ignores any diversification (portfolio) effects.

9. Quantifying Financial Risks

- Value at Risk is not concerned with predicting a particular outcome or attempting to forecast the more likely movements in a risk factor.
- Value at Risk is concerned with estimating the potential spread of outcomes and hence the potential for losses.

Portfolio Returns

- Harry Markowitz won a Nobel Prize for his insights into the process of portfolio construction and optimization.
- Even when the potential returns are unchanged, we can reduce the dispersion of the return with a portfolio of assets.
- For uncorrelated assets, the standard deviation of returns declines at the rate of $E(V) \times 1/n^{½}$, where n is the number of investments in the portfolio.

Calculating Returns

- If a loan were made for $1,000 and the interest paid were $87.50:
  - In absolute terms, the return is $CF_1 - CF_0$ = $1,087.50 - $1,000 = $87.50
  - In percentage terms, $(CF_1 - CF_0) / CF_0 \times 100$ = ($1,087.50 - $1,000) / $1,000 x 100 = 8.75%
- Although it is sometimes useful to know the return in absolute terms, the standardized term allows for easier comparison.

The Normal Distribution

- The behavior of financial market returns can be closely approximated with the normal distribution.
- The attraction of the normal distribution is that, once the standard deviation has been calculated, it allows one to estimate the confidence level or probability that a particular outcome will be within a given range of returns.
  - $z = (x_i - \mu) / \sigma$ where z is the probability on the normal distribution, x_i is the actual observed variable and μ is the mean of the observed variables.

Covariance

- Covariance is a statistic similar to variance.
  - The variance of returns for a single asset is calculated by subtracting the expected return from each of the possible outcomes and then squaring that difference.
  - The covariance is calculated in a similar fashion, except that the deviations from the two expected returns are multiplied together and the relevant probability is now a joint probability.
  - $\sigma_{ab} = \Sigma \rho_i (r_a, r_b) \times [r_{a,i} - E(r_a)] [r_{b,i} - E(r_b)]$

Correlation Coefficient

- The correlation coefficient – a more easily understood statistic – is calculated from the covariance by the following formula:
  - $\rho_{ab} = \sigma_{ab} / (\sigma_a \times \sigma_b)$
  - This takes values between –1 and +1.
  - The degree to which one asset's behavior can be explained by the other asset's behavior is found by the coefficient of determination (R^2), which is the correlation coefficient squared (ρ^2_{ab}).

Portfolio Expected Return

- The expected return form a two asset portfolio is:
  - $E(r_p) = x_a E(r_a) + (1 - x_a)E(r_b)$, where $E(r_a)$ and $E(r_b)$ represent the returns on Assets a and b.
- The more general formulation of the weighted average expected return on a portfolio is given by:
  - $E(r_p) = \Sigma x_i E(r_i)$ such that $\Sigma x_i = 1$

Portfolio Risk

- Whereas the portfolio's expected return is the weighted average of its constituents, the portfolio's standard deviation (in general) is not.
- To calculate the portfolio risk, we require the variance and standard deviation of the individual assets, and their covariance or correlation. For two assets:
  - $\sigma^2_p = x^2_a\sigma^2_a + x^2_b\sigma^2_b + 2x_a x_b \rho_{ab}\sigma_a\sigma_b$ where σ^2_a, σ^2_b and ρ_{ab} represent the variance (standard deviation squared) of asset a, the variance of asset b and the correlation coefficient between a and b.

Minimum Variance Portfolio

- We can establish the least risky portfolio using the following equation:
  - $x^*_a = (\sigma^2_b - \rho_{ab}\sigma_a\sigma_b) / (\sigma^2_b + \sigma^2_b - 2\rho_{ab}\sigma_a\sigma_b)$, where x^*_a is the optimum position in asset a.
  - The term $\rho_{ab}\sigma_a\sigma_b$ is the covariance between a and b.
- When the correlation $\rho_{ab} = 0$, the equation reduces to:
  - $x^*_a = \sigma^2_b / (\sigma^2_a + \sigma^2_b)$
  - In this special case, the benefit of diversification is driven solely by the weighting, and not by any interaction of the variables.

Benefits of Diversification

- The greater the correlation, the smaller the benefit to be had from portfolio diversification – none if the securities are perfectly correlated.
  - $(\sigma_{wa} - \sigma_p) / \sigma_p$ = benefits of diversification
- As the number of assets increases, the effects of the variance terms (equal to n, the number of assets) is overwhelmed by the covariance terms (= n x n – n). At the limit, the risk is equal to the average covariance of all assets in the portfolio:
  - $\sigma^2_p = 1/m(\sigma^2_i) + (1 - 1/m)(\sigma^2_{avg})$
  - As m → ∞, 1/m → 0

Portfolio Design

- For investment purposes, the diversification effect allows the creation of efficient portfolios that either:
  - Maximize return for a given risk or
  - Minimize risk for a given return.
- As the correlation of the assets declines, the opportunity to earn a higher expected return for a given level of risk is increased.

Practical Considerations

- The use of historical information to calculate volatility and correlation make the implicit assumption the the future will be, statistically speaking, like the past.
  - If there is any reason to believe that the future will be different, it will be necessary to adjust the estimates accordingly.
- $VaR_p = (VaR^2_a + VaR^2_b + 2\rho_{ab} VaR_a VaR_b)^{½}$

10. Financial Methods for Measuring Risk

- Two elements are central to risk measurement:
  - the effect of time
  - the effect of a given change in interest rates (or the discounting rate)

  on the value of a future set of cash flows.
- To ensure that a hedge works, we set the sensitivity (or value change) of the futures contract to be the opposite of the position to be managed.

The Present Value Approach

- The discount factor, sometimes called a negative interest rate, is applied to future cash flows: $1 / (1 + r)^t$.
- Sensitivity is measured in terms of the value impact per hundred nominal by a one basis point change (1/100 of one percent) in the interest rate.
  - A partial revaluation – scaling a bp calculation according to size and term – will be accurate only for a small change. Its accuracy depends on the second derivative of present value in respect to interest rates, called convexity or gamma.
  - There is a mathematical approach for discounting fixed cash flows based on the mean discounted term, known as duration.

Spot Discount Rates

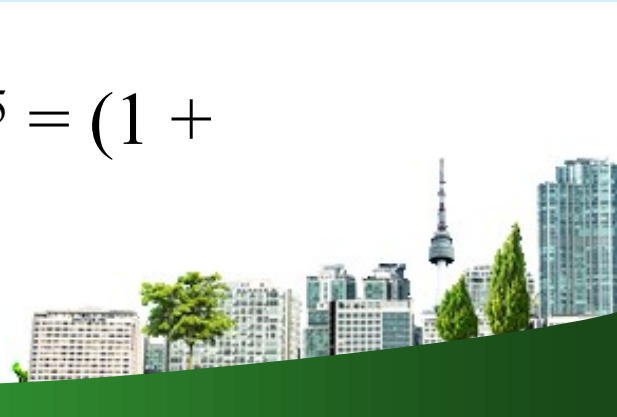
- As the yield curve will (likely) have a shape that implies different discount rates for different maturities, discounting will be simplified by converting those maturities to a spot rate: the yield of a zero-coupon bond (also called 'strips').
- If the cash flows associated with a bond are each discounted by the applicable (periodic) rate (a method called bootstrapping), the last term will be the equivalent of the term's zero-coupon rate. For example, if we have a one-year spot rate of 8%, and a two-year 9% bond selling at 99.50, then:
  - $99.50 = (9 / 1.08) + (109/ (1 + {}_0Z_2)^2$

Spot Discount Rates, 2

- There is a potential bias in discount rates in bonds that are not trading near par.
  - A premium bond – one with a coupon rate higher than the current discount rate – locks in a capital loss if held to maturity (a process known as the 'pull to par'). Its value will be affected by the demand for the tax consequence.
  - There are similar effects created by a discount bond, liquidity and creditworthiness.
  - Where the issuers have different probabilities of default, the difference in yields (internal rates of return) used to value the bond is known as a credit spread.

Term-Structure Approach

- Under the expectations hypothesis, a two-year rate will consist of two one-year rates: the current one-year rate and the expected one-year rate in one year, or the forward rate ($_1F_2$). Generally:
  - $(1 + {}_0Z_m)^m = (1 + {}_0Z_n)^n(1 + {}_nF_m)^{m-n}$
  - $[1 + (m/365)\ {}_0Z_m] = [1 + (n/365)\ {}_0Z_n]\ x\ [1 + (m-n)/365\ {}_nF_m]$
  - With compounding, $(1 + {}_0Z_m)^{m/365} = (1 + {}_0Z_n)^{n/365}(1 + {}_nF_m)^{(m-n)/365}$



Rate Changes

- A change in interest rates might be:
  - A parallel shift, in which all rates in the time horizon increase or decrease by the same amount, or
  - A rotational shift, in which the increase commences at one term (the pivot) and then increases of decreases geometrically over the time horizon.
- If the risk of these events is perfectly correlated, then the combined risk is equal to their sum.
- If the risk of these events is perfectly uncorrelated, then the combined risk is equal to the square root of the sum of their squares.
- Generally, Total Risk = $\sqrt{(\text{Risk}_a)^2 + (\text{Risk}_b)^2 + 2\rho_{ab}\text{Risk}_a\text{Risk}_b}$

Simulation

- Where there is some uncertainty of the relationship between risk factors, a simulation will randomly generate a set of values for each risk factor that are then incorporated in the risk model.
  - Model the situation.
  - Specify a random set of numbers that correspond to the chance of a given outcome.
  - Calculate the present value of the cash flows at risk.
- In general, the larger the number of stochastic elements in a model, the more likely it is that simulation is the desired evaluation method.

11. Qualitative Approaches

- A model that uses historical data to assess risk cannot be used if:
  - There is no data
  - The future is expected to be significantly different than the past (including a change in direction)
- The planning exercise requires management to examine the future and the potential risks that may prevent the firm from realizing its objectives.
  - A capital-intensive firm will have a longer planning horizon.

Methods

- Delphi
  - Each member anonymously records comments and suggestions. These are gathered and sent to the other members.
  - Members provide feedback on other members' comments.
  - Process continues until consensus is reached: not usually a point estimate but a narrow spread of opinion.
- Expert Judgment
  - This can be a single individual or a group. Members of the panel use information and methods each considers appropriate.

Methods, 2

- **Scenario Writing**
  - involves developing one or a set of plausible outcomes over the forecast period based on a well-defined set of assumptions.
- **Brainstorming**
  - Key to participation is to separate idea generation from idea evaluation.
  - Evaluate each on its merits.
  - Accountability is not required so creativity is more abundant and less inhibited.
  - In risk management, we are at times attempting to think the unthinkable. A logical thought process is probably ill-suited to the task.

Problems

- Since the approach is largely heuristic, it is difficult to check the validity of the assumptions.
- There may be a forecast bias: a systematic, subjective element that reflects the forecaster's 'world view'.
- Model risk: a simplification of the real world may not include all the relevant elements or ignore relationships such as causality. Therefore, the model may be misspecified and not provide a good enough fit when used.

12. Financial Appraisal

- Assessing credit risk requires a modeling of the probability of a counterparty defaulting in full, or in part, on its obligation.
- *Ex ante*, the decision alternatives have the following payoffs:
  - Refuse credit: 0
  - Extend credit:
    $[PV(Revenue - Costs) \times (1 - \rho)] - PV(Cost) \times \rho$
    where ρ is the probability of default
  - Part of the assessment process is a calculation of the exposure that arises.

The Trade-off

- In their day-to-day activities, firms seek to trade off credit risk against potential gains and losses. These arise not just from accepting bad credits, but also in rejecting good ones:
  - Type I error: Assessing bad credit as good results in expected risk of loss
  - Type II error: Assessing good credit as bad results in lost opportunity
  - More effort is expended in trying to avoid Type I errors than Type II errors, because the costs of extending credit in a default situation are far greater than the opportunity foregone by refusing credit to the good risk.

Credit Assessment

- Financial theory postulates that there should be return at which the grantor is compensated for the risk taken, and still enter the transaction. They key is in finding the links between a firm's financial condition and default.
- Four approaches:
  - Qualitative model
  - Relationship model
  - The 'Z-score' statistical model
  - The credit scoring or 'A-model'

Qualitative Processes

- …aim to provide a view based on perceptions of the environment in which the firm operates and the intention of the credit.
- The best known of these approaches is "The Six C's of Credit":
  - Character: consistency, honesty, integrity, responsibility
  - Capacity: ability to generate the required cash flow
  - Capital: equity in the firm
  - Collateral: amount of security provided
  - Conditions: economic and business environment
  - Compliance: *ultra vires,* unsuitable product offering, executing against a foreign counterparty

Financial Statements

- There are two principal sets of information available to the analyst:
  - Balance sheet: a cross-sectional picture of the firm's financial condition on a particular date. The netted-down presentation shows the relationship between the firm's income-generating assets and the nature of its liabilities, that is, the source of finance.
  - Income statement: The firm's revenues and expenses over the accounting period. There are normally three separate parts – (a) the trading account, (b) overhead, and (c) the allocation between dividends, taxes and retained earnings.

Financial and Ratio Analysis

- Absolute figures are not helpful by themselves. A ratio reduces the data to a workable form and makes it more meaningful.
- Percentages or ratios permit easy comparison between periods or different corporate entities.
- They remove the effect of size.
- Trends are usually more meaningful that a single period analysis.
- Differences in definition are ultimately less important than consistent application.
- Beware that ratios may suppress poor absolute figures.

Credit Ranking

- The financial ratios, their trends and qualitative information (the six C's) builds up a picture of the credit. The company is then assessed, ranked or compared to previously-analyzed companies to determine the credit quality.
- A weight is assigned to each of the scores according to their significance in the final ranking.
- The aggregate score determines an overall ranking, wherein company issues in the same credit range tend to be treated as being nearly equivalent.

Activity Ratios

- … show how efficiently the management is using its resources.
- Average Collection Period = Debtors / Sales per day
- Inventory Turnover = Sales / Inventory
- Fixed Assets Turnover = Sales / Net Fixed Assets
- Total Assets Turnover = Sales / Total Assets

Liquidity Ratios

- …measure a company's ability to meet its maturing short-term obligations
- Current ratio = Current assets / Current Liabilities
- Quick Ratio (Acid Test) = (Current Assets – Inventory) / Current Liabilities
- Fixed to Current Asset Ratio = Fixed Assets / Current Assets

Operating Ratios

- …assess how well the organization is managing its operations.
- Profit Margin = (Sales – Cost of Sales) / Sales
- Net Profit Margin = Net profit after taxes / Sales
- Free Cash Flow = Depreciation + Profit after Tax ± Deferred Tax

Profitability Ratios

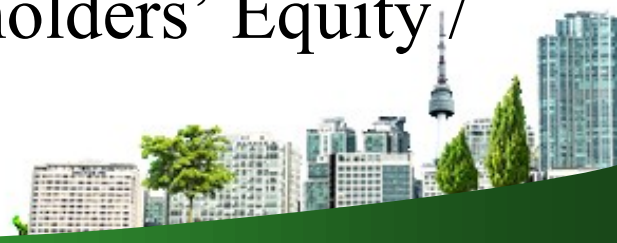
- …show the management's ability to generate profits.
- Return on Total Assets (ROI) = Net profit after taxes / Total Assets
- Return on Capital Employed (ROCE) = EBIT / Total Assets
- Return on Owners' Equity = Net profit after taxes / Owners' Equity

Risk Ratios

- … show the amount of financial risk taken by the firm in its operations and from its capital structure.
- Debt-to-Equity Ratio = Debt (long- and short-term) / Total Equity
- Debt Ratio = Total Debt / Total Assets
  - Creditors look to the owners' equity to provide a margin of safety. Companies with low gearing ratios have less risk of loss in economic downturns, but also have lower returns when the economy performs well.
- Times Interest Earned = (Profit before tax + Interest Charges) / Interest Charges
- Fixed-charge coverage = EBIT + Lease Payments / Interest + Lease Payments + Pre-tax Pref. Dividends

Market-Based Ratios

- … show investors' assessment of the company's performance based on market valuations.
- Earnings per share = Earnings after tax and minorities / # shares
- P/E Ratio = Market price per share / Current earnings per share
- Price-to-Book Ratio (P/BV) = Market price per share / Book Value per share
- Net Asset Value per share = Shareholders' Equity / # shares



Analytic Relationship Models

- The key to the DuPont system is the separation of management performance from financing decisions.
- The Return on Assets term is interpreted as a measure of management's business decision making ability: ROA = (EBIT - Taxes) / Total Assets.
- The Return on Equity term includes the effect of financing decision on the shareholders' return: ROE = (EBIT – Taxes – Interest) / Equity.
- The analyst can see how the ROA/ROE results are being achieved and, if necessary, drill down into specific components of the performance.

13. Modeling Credit Risk

- The statistical approach to credit analysis takes as its foundation observed outcomes from a sample of firms: “bad” ones where default or bankruptcy has taken place, and “good” ones where it has not (or has not yet).
- The theory is that statistical methods can be used to find a set of variables about the credit that are, in combination, significantly related to default.
  - A scoring model, employing a statistical technique called Discriminant Analysis, will indicate whether the applicant has characteristics in common with good credits or bad credits.

Z-score models

- A cut-off point is designed to minimize the number of bad firms misclassified as good, a firm will be rejected or the terms modified.
- These “Z-score” models use the following categories of ratios in the predictor equation: activity, leverage, liquidity, profitability and solvency.

Altman Z-score

- The model developed by Edward Altman (1968) for firms defaulting within one year:
  - Z-score = $0.12\ X_1 + 0.14\ X_2 + 0.033\ X_3 + 0.006\ X_4 + 0.999\ X_5$
  - X_1 is Working Capital / Total Assets (Liquidity)
  - X_2 is Retained Earnings / Total Assets (Profitability)
  - X_3 is EBIT/ Total Assets (Solvency)
  - X_4 is Market Value of Equity / Book Value of Total Debt (Leverage)
  - X_5 is Sales / Total Assets (Activity)

Altman Z-score Predictions

- > 2.99
- 2.99 – 1.81
- < 1.81

- Firm would not default within one year
- Indeterminate area where it us difficult to discriminate between good and bad firm
- Analyzed firm would default within one year

Characteristics of Defaulting Firms

- Secular or cyclical decline in demand for the firm's products and services (trend analysis, declining profitability)
- Poor-quality senior management (management ratios, profitability)
- Lack of centralized financial controls (activity and management ratios)
- Poorly planned, integrated and managed business acquisition, with higher risk if the acquisition is a non-related area (decline in profitability, high overheads, decline in share price)

Defaulting Firms, 2

- Inappropriate product and/ or marketing strategy (declining market share)
- High overheads (high overhead ratio to total sales, low profitability)
- Poor working capital management (activity ratios)

Company Scoring

- Given that failure tends to be people-driven and that analysis (by default) uses historical information, John Argenti (1977) developed a Corporate 'A-score' model that explicitly sought to rate the risk of poor management causing corporate failure.
  - Group A: management and accounting defects (total of 43, with score of 10 or higher indicating impairment)
  - Group B: management mistakes (total of 45, with threshold of 15)
  - Group C: symptoms of trouble (total of 12, without similar threshold)
  - Total: 100, with threshold of 25.

Credit Scoring

- Credit scoring applies a numerical approach to quantitative and qualitative variables, taking a number of facts about the credit into account and relating these to previous default experience.
- The analysis may seek a best-fit discriminating equation (a logit regression) in which the dependent variable is bad debt (value = 0) or good credit (value = 1).

Dynamic Scoring Model

- The problem with many approaches is that they are static or one-off assessments made prior to the initial decision to extend credit.
- Dynamic scoring models incorporate facts about the credit over time into the decision to extend or renew an exposure.
  - The might include the payment history with respect to this credit.
  - The credit review may also use as inputs a sample of other creditors to estimate the probability of moving from one credit state to another (an event known as ‘credit migration’; a statistical process known as a ‘Markov chain’).

Advantages and Limitations

Advantages

- Since the model makes explicit assumptions and criteria based on research, decisions can be validated.
- Assessments use a common methodology (comparability).
- Management control

Limitations

- Overcoming creative accounting
- Data are historical, and both the business cycle and business circumstances may change.
- Models are only as good as the estimates used to create them.
- Theoretical shortcoming: not measuring directly the causes of default