

Module A Setting the scene

[The use of credit scoring technologies] has expanded well beyond their original purpose of assessing credit risk. Today they are used for assessing the risk-adjusted profitability of account relationships, for establishing the initial and ongoing credit limits available to borrowers, and for assisting in a range of activities in loan servicing, including fraud detection, delinquency intervention, and loss mitigation. These diverse applications have played a major role in promoting the efficiency and expanding the scope of our credit delivery systems and allowing lenders to broaden the populations they are willing and able to serve profitably.

Alan Greenspan, U.S. Federal Reserve Chairman, in an October 2002 speech to the American Bankers Association.¹

Our modern world depends upon credit. Entire economies are driven by people's ability to 'buy-now, pay-later'. Indeed, two hundred years ago it was a privilege to borrow money, but in today's industrialised societies it is considered a right. Providing credit is a risky business though, as borrowers differ in their ability and willingness to pay. At the extreme, lenders may lose the full amount, and perhaps even get sucked in for more. In other instances, they may lose only a part, or just incur extra costs to get the money back. It is a gamble, and lenders are always looking for means of improving their odds.

Over the last fifty years, automation has extended beyond the back-office functions of accounting and billing, and moved into the domain of decision-making. Its influence has been greatest on credit provision, where the much improved risk assessments have empowered lenders to lend where they once feared to tread, and improved processes have aided accessibility for the general public. For people applying for credit, it is often a black box though—they know what goes in and comes out, but not what happens inside. If you apply for a loan, you are told either 'yes' or 'no'. If 'yes', you are told the amount you can borrow and the repayment terms. If 'no', you either slink away with your tail between your legs, or go to the lender next door and try again. And if the latter, or if you do not like the repayment terms, it is often difficult to get an adequate explanation of 'Why?' Much of the problem arises because of a poor understanding of what goes on behind the scenes, even by lenders' own employees. This textbook covers the topic, and the first module has three chapters:

- (1) **Credit scoring and the business**—Covers what credit scoring is, where it fits within the business and the economy, and how it has affected us.

¹ <http://www.federalreserve.gov>, quoted in Mays (2004:4).

- (2) **History of credit**—A micro-history of the provision of credit, credit scoring, credit bureaux, and credit rating agencies.
- (3) **Mechanics of credit scoring**—An overview of how credit scoring works, especially as regards scorecard development.

Chapter 1 starts the module, using a *FAQs framework* to address several questions: (i) What is credit scoring?—which treats the parts (‘credit’ and ‘scoring’) before considering the whole (‘credit scoring’), and delves into the economic rationale, including concepts such as asymmetric information, adverse selection, moral hazard, and information rents; (ii) Where is it used?—a brief look at the processes, data sources (customer, internal, and external), credit risk management cycle (CRMC), and behavioural propensities (risk, response, revenue, and retention); (iii) Why is it used?—especially the quality, speed, and consistency of decisions, and how these have affected lenders and consumers; and (iv) How has it influenced the credit industry?—its broader impact, with particular attention paid to data, risk assessment, decision rules, process automation, and regulation.

Wherever possible in this textbook, historical background has been provided to put concepts in context. *Chapter 2* is dedicated to *history*, including: (i) credit provision—from the first documented use of credit in ancient Babylon, through to the evolution of credit cards and risk-based pricing; (ii) credit scoring—from the time it was first proposed in 1941, through the establishment of Fair Isaac in 1958, to the evolution of bureau scores, and scoring’s use in securitisation; (iii) credit bureaux—from the origins of Dun and Bradstreet in the 1840s, through to the more recent evolution of Experian, Equifax, and Transunion; and (iv) credit rating agencies—including Moody’s Investor Services from 1909, as well as Standard and Poor’s and Fitch IBCA.

Credit scoring is a technical area, and *Chapter 3* touches on the *mechanics*: (i) scorecards—form and presentation, development, how good are the predictions?, how does scorecard bias arise?, and what can be done about it?; (ii) measures used—whether as part of the business process, assessment of scorecard performance, or the default probability and loss severity measures used in finance functions; (iii) development process—covering project preparation, data preparation, modelling, finalisation, decision-making and strategy, and security; and (iv) changes that can affect the scorecards—including the economy, marketing, operations, and societal attitudes towards debt.

These provide the 25¢ tour of credit scoring, after which the reader should have a broad overview of the topic. It may be enough by itself, or just set the scene for the rest of the book.

Module B Risky business

While microprocessors used in workstations are doubling their capacity practically every year, demands posed by the user population grow much faster.

Dimitris Chorafas (1990)

When the term ‘credit scoring’ is uttered, different people think of different things: *customers*, the credit application form and the ensuing call to the credit bureau, and possibly the last time they were refused credit; *statisticians*, the predictive-modelling tools used to derive the risk rankings; *lenders*, the cut-off and limit strategies used to improve their bottom line; and for *IT staff*, the systems required to calculate the scores, apply the strategies, and deliver the final decisions.

This section focuses on the business aspects—the strategic justifications for why, when, where, and how it should be used. In some cases, the topics are grouped together just because they seem to fit together, yet they are quite distinct:

- (4) **Theory of risk**—Frameworks for considering risks to the broader organisation, where credit risk is only one of them.
- (5) **Decision science**—Credit scoring allows case-by-case risk management, but use of scientific methodologies allows even greater value to be extracted.
- (6) **Assessing enterprise risk**—A look at lending to businesses of any size, including traditional frameworks, and recent developments.

Risk is a part of any endeavour, but over the past few decades, it has become a specialist function within organisations. *Chapter 4* looks at broader *risk frameworks*: (i) the risk lexicon—highlighting risk linkages, the playing field (company proposition, physical resources, and market, economic, social, and political factors), and risk types (primarily business, credit, market, and operational, but also others falling under business environment, business dealings, extraterritorial, personal, and intelligence) and (ii) data and models—looks at data types (which can vary by source, time, inputs, indicators, and view), and model types (statistical, expert, hybrid, and pure judgement). Some risk types are easier to model than others, and frameworks are presented showing how the type of credit risk model used is typically a function of structure and technology, and the volume of deals and profit per deal.

In order to reduce risk, businesses strive for greater control, which can be aided by having proper policies, procedures, structure, and infrastructure. Businesses have made increasing use of scientific methods to provide greater structure. *Chapter 5* looks at *decision science*, including: (i) adaptive control—where processes are adjusted to maintain consistent output and (ii) experimentation and analysis—including champion/challenger, optimisation, simulation, and

strategy inference. A framework is presented, illustrating that the strategy chosen should be determined by an event's probability and potential impact.

Credit scoring originated in the consumer credit arena, but is increasingly replacing (or supporting) traditional enterprise risk assessments. *Chapter 6* covers lending to *business enterprises*: (i) basic credit risk assessment—covering the traditional 5 Cs, data sources (securities prices, financial statements, payment history, environmental assessment, and human input), and risk assessment tools (agency grades, business report scores, and public/private firm, hazard, and exposure models); (ii) SME lending—and forces driving lenders from relationship to transactional lending; (iii) financial ratio scoring—covering pioneers, predictive ratios, rating agencies, and internal grades; (iv) credit rating agencies—their letter grades, derivation, and issues (small numbers, population drift, downward rating drift, business cycle sensitivity, and risk heterogeneity within the grades); (v) modelling with forward looking data—covering straightforward historical analysis, structural approaches (Wilcox's gambler's ruin, Black and Schole's options-theoretic), and the reduced-form approach (proposed by Jarrow and Turnbull, which is based primarily on the credit spreads of bonds' market prices).

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Module C Stats and maths

To chop a tree quickly, spend twice the time sharpening the axe.

Chinese proverb

The concept of data mining evolved during the 1990s, as classical statistics, artificial intelligence (AI), and machine learning techniques were harnessed to search data for non-obvious patterns, and knowledge. It is similar to conventional mining in that: (i) vast volumes have to be processed just to yield a few gems and (ii) it requires its own picks and shovels, assayers' scales, and people who know how to use them. Credit scoring might have started thirty years earlier, but is nonetheless considered part of the same arsenal (under 'classical statistics'). Computing power was limited in the early days though, and the use of predictive statistics to drive production processes—especially selection processes—brought with it new challenges. As a result, some practices are specific to this environment, and may provide a competitive advantage. Even so, businesses' interest today lies less in statistical tricks, and more in making better use of data, and getting maximum value out of the resulting scores.

Nonetheless, credit scoring cannot be discussed without covering the statistical techniques used. Such concepts are normally covered when discussing the Scorecard Development Process (Module E), but here they are instead treated as basic building blocks, primarily because many of them are used at different stages in the process, and thereafter. These include

- (7) **Predictive statistics**—Methods for providing estimates of unknown values, whether future events or outcomes, that are difficult to determine (high cost or destructive).
- (8) **Measures of separation and accuracy**—Calculations used to provide indications of the power and stability of both predictors and predictions, and the accuracy of predictions.
- (9) **Odds and ends**—A collection of topics, including descriptive modelling techniques, forecasting tools, some statistical concepts, and basic scorecard development reports.
- (10) **Minds and machines**—A look at the required people (scorecard developers, project team, steering committee) and software (scorecard development, decision engines).

As indicated, credit scoring has been built upon *predictive statistics*. *Chapter 7* starts by describing some of the statistical notation, and moves on to: (i) an overview of the techniques—including modelling and data considerations when using them; (ii) parametric techniques—linear regression, linear probability modelling (LPM), discriminant analysis (DA), and logistic regression; and (iii) non-parametric techniques—recursive partitioning algorithms (RPAs, used to derive decision trees), neural networks (NNs), genetic algorithms, K-nearest

neighbours, and linear programming; (iv) critical assumptions—covering treatment of missing data, statistical assumptions for parametric techniques (relating to variables and model residuals) and how violations can be addressed; and (v) a comparison of results—which provides no clear winners, although logistic regression leads the fray based purely on popularity.

Besides just developing the models, the results have to be measured. *Chapter 8* looks at *measures of separation/divergence* used to assess both power and drift, including: (i) the misclassification matrix and a graphical representation; (ii) the Kullback divergence measure, including the weight of evidence upon which it is built, information value, and stability index; (iii) the Kolmogorov–Smirnov statistic and associated graph; (iv) correlation coefficients and equivalents—covering Pearson’s product-moment, Spearman’s rank-order, the Lorenz curve, Gini coefficient, and receiver operating characteristic; and (v) Pearson’s chi-square—which measures the difference between frequency distributions. Further, section (vi) deals with measures of accuracy—starting with probability theory (and Bernoulli trials), before covering the binomial test (and its normal approximation), Hosmer–Lemeshow statistic, and log-likelihood measure.

Chapter 9 covers *odds and ends* that do not fit neatly elsewhere, including: (i) descriptive modelling techniques used for variable reduction—cluster analysis (for records) and factor analysis (for variables); (ii) forecasting tools—including transition matrices/Markov chains and survival analysis; (iii) an explanation of some statistical concepts—such as correlations, interactions, monotonicity, and normalisation; and (iv) basic scorecard development reports—characteristic analysis, score distribution, and the new business strategy table.

Finally, there are issues relating to the *minds and machines* used to develop credit-scoring models. *Chapter 10* covers: (i) people and projects—scorecard developers, external vendors/consultancies, internal resources, project team, and steering committee and (ii) software—for scorecard development (which may be user-friendly, but have limited transparency and flexibility), and applying the models and making decisions within the business (decision engines).

A polysyllabic overview

It might also help to briefly describe some of the high-level terms used in this domain. As can be seen from the above, it is impossible to keep the discussion monosyllabic, but most of the words only just rival ‘television’ in terms of the number of syllables.

Predictive/descriptive/forecasting—Defines the model’s purpose. *Predictive*—develop models that provide an estimate of a target variable (regression techniques, RPAs, NNs). *Descriptive*—find patterns that describe the data, whether the records (cluster analysis) or the variables (factor analysis). *Forecasting*—tools used for prediction at an aggregated level, including movements between states (Markov chains/transition matrices) and mortality rates (survival analysis).

Parametric/non-parametric—Defines whether the modelling technique or test makes assumptions about the data. *Parametric*—makes assumptions, such as a normal distribution, linearity, homoscedasticity, and independence (linear regression, logistic regression,

DA). *Non-parametric*—makes no assumptions, and it is used where the parametric equivalent cannot be used (RPAs, AI).

Statistical, operations research, AI—Defines the discipline where the technique originated.

Statistical—linear regression, logistic regression, and RPAs. *Operations research*—linear programming, and other methods used for resource allocation and logistics. *AI*—newer approaches, such as NNs, genetic algorithms, K-nearest neighbour, and machine learning.

Algorithmic/heuristic—Defines the development procedure. *Algorithmic*—defined by a formula, or set of steps (regression techniques, RPAs). It also applies to the use of strict policy rules in any part of the business process. *Heuristic*—based upon empirical data analysis, but uses trial and error, to come up with a result that has no explicit rationalisation (NNs, genetic algorithms). The term also applies where expert judgement is used to set rules of thumb or flexible guidelines.

Deterministic/probabilistic—Defines the level of certainty in the relationship.

Deterministic—outcomes can be exactly determined using a formula/algorithm, which is more often the case in hard sciences such as physics. *Probabilistic*—definite outcomes cannot be determined, but probabilities can be derived (associated with stochastic processes and ‘fuzzy’ logic).

Labels such as these are used in different environments – finance, engineering, science, psychology, and so on, and the techniques that are appropriate in each will vary according to the problem. Credit scores are developed using predictive models, which are usually parametric, statistical, algorithmic, probabilistic, regression models, used to represent a stochastic process with a binary good/bad outcome. Non-parametric and heuristic AI techniques may also be used, but are not as widely accepted.

An apology must be made here! It is one thing to digest a single multi-syllable word, but quite something else to handle so many in quick succession. Hopefully though, these explanations will allow the reader a better understanding of the following chapters, and other literature on the topic.

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Module D Data!

Without data the modern commercial opportunities would be very limited. Data and information (and they are different from each other) are fundamental to the success of any business today and they increasingly provide a commercial competitive edge.

McNab and Wynn (2003:17)

Decisions can only be as good as the information upon which they are based, which is why spies, industrial espionage, and private investigators exist—along with other under-handed ways of trying to get the upper hand. Unfortunately, there is often a laxity about the data that is gathered, which may be insufficient, of poor quality, or difficult to interpret. Poor intelligence has been the undoing of countries and companies, generals, CEOs, and others in highly competitive situations. Information is crucial!

Most literature on credit scoring focuses on the statistical methods used, and pays scant attention to data. Indeed, the starting point—and often more difficult task—is to ensure that relevant and reliable information is available for both scorecard development and business processes where the scorecards are applied. This does not mean that the role statistical methods play is less relevant; only that the cumulative organisational investment in obtaining and managing credit intelligence is greater. Indeed, data problems can result not only in financial losses, but also lost sleep and lost sanity.

Advances in technology since 1960 have significantly increased the quantity and quality of available credit intelligence, especially in terms of (i) the number of data sources; (ii) the amount of relevant information provided; and (iii) the ease with which it can be acquired, analysed, and summarised. There has also been a credit explosion in both developed and developing economies, especially for people who did not previously qualify. This chapter covers data in some detail, under the following headings:

- (11) **Data considerations**—Factors that must be in place before a scorecard can be built, and issues relating to the characteristics used as predictors.
- (12) **Data sources**—Discusses the types of information obtained from the customer, internal systems, and the credit bureaux.
- (13) **Scoring structure**—Looks at scorecard customisation and hosting, data integration, and matching data from various sources.
- (14) **Information sharing**—Describes the types of credit registries, the reason for their existence, how they operate, and what motivates or inhibits lender participation.
- (15) **Data preparation**—The first stage of the scorecard development process, covering assembly, the good/bad definition, sample windows, and sample selection.

Chapter 11 looks at *data considerations*—starting with (i) transparency—a prerequisite for credit scoring; (ii) data quantity—depth and breadth (including minimum requirements), issues around homogeneity/heterogeneity, and accessibility; (iii) data quality—relevant, accurate, complete, current, and consistent; (iv) data design—data types (both statistical and practical classifications, as well as manipulation and special cases like missing data and division by zero), and form design issues for both categorical and numeric characteristics.

Nothing would be possible without *data sources*, which are the focus of *Chapter 12*: (i) customer supplied—including the application form and supporting documentation; (ii) internal systems—which provide both performance and predictors; (iii) credit bureau data—enquiries/searches, publicly available information, and shared performance; (iv) fraud warnings—known frauds, third-party data, and special information sharing arrangements; (v) bureau scores—which summarise available bureau data into propensity measures, especially risk; (vi) geographic indicators—including geographic aggregates and lifestyle codes; and (vii) other miscellaneous sources.

There are a lot of data issues that do not fit neatly elsewhere, which are covered in *Chapter 13* under *scoring structure*: (i) customisation—looks at generic and bespoke scorecards, and factors influencing which is most appropriate; (ii) hosting—whether to execute the scorecard on internal or external systems; (iii) data integration—which may be independent, discrete, or consolidated; (iv) credit risk scoring—looks at customisation and integration for each stage in the CRMC; and (v) matching—covers issues on how records from various sources are linked.

Perhaps the greatest advances in credit risk assessment have come from lenders' cooperation. *Chapter 14* provides a broad view of *information sharing*: (i) credit registries—public versus private registries (including which operate where, and why), and positive versus negative data; and (ii) do I or don't I?—principles of reciprocity governing such arrangements, and motivators/inhibitors to participation.

Finally, *Chapter 15* looks at *data preparation*, the first real stage of the scorecard development process: (i) data acquisition—for application data, bureau data, own current and past dealings, performance data, and initial data assembly; (ii) the good/bad definition—which is split into selection statuses and performance statuses, and also covers definition setting (consensus, prescribed, or empirical), and what a good/bad definition should be; (iii) observation and outcome windows—considerations when setting sampling windows, including maturity, censoring, and decay, especially for application and behavioural scoring; and (iv) sample design—covers sample types (training, holdout, recent, etc.), minimum and maximum sample sizes, and stratified random samples.

Module E Scorecard development

If one has sufficient data and wishes to make a scoring model, the following objective helps: aim to make a model that has equal power but is simpler or more transparent than its alternatives. That is, instead of focussing on increasing power, which often leads to overfitting, focus on simplifying a well-known model's structure or data inputs. This is a much more promising way to add value, playing on the fact that most models are overfit.

Falkenstein (2002:185)

One wonders if Mr. Falkenstein was aware that he effectively restated the centuries-old philosophy known as Ockham's Razor, or the 'principle of parsimony', according to which 'of two alternative explanations for the same phenomena [sic] the more complicated is likely to have something wrong with it, and therefore, other things being equal, the more simple is likely to be correct'.

William Ockham was a fourteenth-century philosopher, whose arguments caused Aristotelian nominalism to triumph over Platonic realism, and who is associated with his own brand of nominalism. He was also known for contesting the power of the papacy, outside of religious affairs.—*Collins English Dictionary*, 21st Century Edition.

This was qualified by Albert Einstein, who commented, 'Everything should be as simple as possible, but not simpler'. These quotations are not just of passing interest, but highlight the need for structure and simplicity, no matter what the endeavour. While this text might not seem to be sticking to that principle, it is at least making an effort.

Falkenstein et al. (2002:20) make reference to studies in economics, which have shown that 'naïve' models consistently outperform more sophisticated alternatives, where "naïve" does not mean uninformed or arbitrary, but parsimonious and informed by theory'.

Philosophy aside, by this stage we are like a medical intern reporting for the first emergency room rotation—all the right training and equipment, but little practical experience beyond television ER dramas. In the ideal world, one should be able to jump right in and assist, but may freeze when the first real-life trauma case arrives. Likewise, when developing models, a set of data and a statistical technique are not enough. One needs to know what to do with them, otherwise the results will be similar to the emergency room scenario above.

Let us recap briefly. Module A sets the scene, covering economic theory and history. Module B views credit risk within the broader risk framework, issues with risk quantification, and assessment of business enterprises. Module C looks at statistical theory and scorecard development tools, which should assist when the more practical aspects of the scorecard development process are considered. And Module D covers data, including the data assembly process, required to provide the predictor and target variables (which is often the hard part; sample design and construction can take weeks, or even months). This section moves on to scorecard development, both: (i) milestones, where contact with the business is required and (ii) process, some of which requires no business input.

Milestones

Unfortunately, scorecard developers and project teams will never have a full view of the business. Just as a ship's engineer relies upon information from the bridge, scorecard developers rely upon management for insights about the business's past, and its proposed future. Questions have to be asked whenever inconsistencies arise, and assumptions must be documented as part of the development. For this reason, the entire scorecard development process must be as interactive as possible. Key milestones that should require presentations to, and possibly approval from, company decision-makers, are

- Start-up**—Initial meetings to determine responsibilities, project scope, possible data sources, and problems that may be encountered,
- Data assembly**—Data sources and sample sizes, where appropriate,
- Good/bad definition**—Not just good, bad, and indeterminate, but also any accounts that are supposed to be excluded from the development,
- Scorecard splits**—Determine whether or not any groups need to be treated separately. Past scorecard splits, and input from the business, provide the best starting point,
- Final scorecards**—The results of the development, including point scores associated with the different attributes for each scorecard, and any validation that has been done,
- Strategies**—Decision to be applied in each scenario, where scores are part of the scenarios. These may be simple cut-offs, but are often more complex.

The final deliverable is not just the scorecard and strategies, but also documentation covering various aspects of the scorecard development process, including data sampling, scorecard splits, characteristic analyses, statistical methods, scorecard validation, and the specifications necessary for implementation into the delivery system—whether by hard coding (possibly including the program code), or just modifying parameters.

Ultimately, the decision-makers will be most interested in scorecard implementation and strategies, and the latter may change over time. At any point post-implementation, the scorecard developer and project team may be brought back in, to ensure that the scorecards are working to design, and to keep management apprised of scorecard effectiveness.

Scorecard Development Process

The development process involves more than just these milestones. This module assumes that data assembly is finished, and covers all aspects required to develop a scorecard, whether presented to business or not. Much of it is conceptually difficult, but a skilled scorecard developer can work through it quite quickly. Unfortunately, there are a number of different ways in which scorecards can be developed, with a variety of factors influencing the choices. The primary influences are (i) the amount of available data; (ii) the implementation platform; and (iii) available skills. It is impossible to cover all of the different possibilities, and many scorecard developers will contest—perhaps rightly—what is being written here. Fortunately, this text is not aiming for the lofty heights of a scientific treatise, but instead hopes to provide the reader with some insight into the choices that are available.

The scorecard development process is illustrated in Figure E.1., which splits it into a full and simple process, the latter being a recurring and time consuming sub-process. This module gives each stage individual treatment:

- (16) **Transformation**—Analyze available data and turn it into something useful, which traditionally involves (i) fine classing; (ii) coarse classing; and (iii) conversion.
- (17) **Characteristic selection**—Choose candidates for consideration, which are predictive, logical, stable and available, compliant, customer related, and uncorrelated.
- (18) **Segmentation**—Determine whether different scorecards are required, and how many. The split may be driven by market, customer, data, process, or model-fit factors.
- (19) **Reject inference**—For an application scoring development, or any model used to drive a selection process, performance of rejected accounts should be inferred.
- (20) **Calibration**—Use of banding or scaling to ensure score results have the same meaning across scorecards, and to provide default probabilities.
- (21) **Validation and delivery**—Test for overfitting and potential model instability using holdout and recent samples, and prepare the scorecards for presentation to business.
- (22) **Development management issues**—Scheduling and streamlining of scorecard developments.

The first part of the development process is to put data into a usable form. *Chapter 16* covers *transformation*: (i) methodologies—both univariate and bivariate, especially the latter’s dummy variable and weight of evidence approaches; (ii) classing—the characteristic analysis report, and binning of both categorical and numeric characteristics; (iii) use of statistical measures—including the chi-square statistic, Gini coefficient, and information value; (iv) pooling algorithms—adjacent, non-adjacent, and monotone adjacent; and (v) some practical examples—court judgements, industry, and occupation.

The number of variables at the start can be significant, but can be reduced prior to starting the development. *Chapter 17* focuses on *characteristic selection*: (i) considerations for inclusion—including significance, correlation, available and stable, logical, compliant, and customer-related; (ii) measures of significance—again the chi-square statistic, Gini coefficient, and information value; (iii) data reduction methods—factor analysis, correlation assessment,

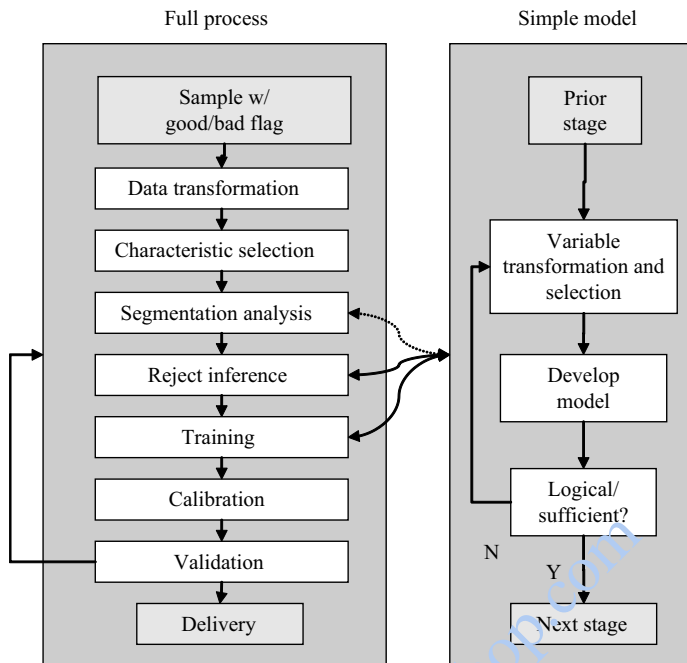


Figure E.1. Scorecard development process

or treat during training; and (iv) variable feed—covers stepping (forward, backward, and step-wise) and staging (independent and dependent).

Companies are used to splitting their customer base for marketing, and the same applies for credit. *Chapter 18* looks at the *segmentation*: (i) drivers—including marketing, customer, data, process, and model-fit factors; (ii) identifying interactions—whether through manual review or use of an RPA; and (iii) addressing interactions—use of scorecard splits and identifying which is best.

With any selection process, there will be discarded cases that might have yielded decent results had they been kept. In credit scoring, *reject inference* is used to guess what rejects' performance would have been, had they been accepted. *Chapter 19* covers the topic, including: (i) why reject inference?—the logic behind it, intermediate model types (known good/bad and accept/reject), and the potential benefits (or lack thereof); (ii) population flows—a tool for assessing changes to the frequency distribution; (iii) performance manipulation tools—including reweighting, reclassification, and parcelling; (iv) special categories—policy rejects, not-taken-ups, indeterminates, and limit increases; and (v) reject inference methodologies—random supplementation, augmentation, extrapolation, cohort performance, and bivariate inference.

There is no specific section covering *training*, as most of the concepts are covered elsewhere. Thus, *Chapter 20* moves on to *calibration*: (i) banding into groups—including use of the Calinski–Harabasz statistic, benchmarking, and marginal risk boundaries; (ii) linear shift and scaling—minor changes to ensure scores from different scorecards have the same meaning,

conversion into numbers that can be better used by business (and some of the features required), and a possible method of achieving it using linear programming.

Checks and balances are required not only immediately after the development, but also ongoing thereafter. *Chapter 21* covers validation, which, for the most part, uses Basel II frameworks: quantitative (conceptual soundness) and qualitative (predictive power, explanatory accuracy, stability) factors; expected loss parameters (PD, EAD, LGD, and M); and process components (data, estimation, application, and mapping). The chapter itself focuses primarily on (i) actions—review of developmental evidence (including scorecard presentation), ongoing validation, and backtesting (including analysis of score shifts); and (ii) disparate impact—which looks more specifically at American anti-discrimination requirements.

Finally, a couple of scorecard development *management issues* are covered in *Chapter 22*: (i) *scheduling*, emphasis must be put on getting value for effort spent; and (ii) *streamlining*, piggybacking on what has been done before, to speed development.

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Module F Implementation and use

There are three important systems and programming issues that relate to credit-scoring projects (1) scorecard installation, (2) connectivity with credit information, and (3) once the scoring process has been completed, scorecard tracking.

Wiklund (2004)

It is now assumed that there are one or more scorecards, and this module moves on to their implementation and use within the business. Much of it follows the outline provided by Wiklund (2004), but other issues are also covered. It is split into four sections.

- (23) **Implementation**—Issues for greenfield developments when scoring is first used, and immediate issues relating to data, resources, and migration for brownfields.
- (24) **Overrides, referrals, and controls**—Checks and balances, used to ensure that the scores are used appropriately, and effectively.
- (25) **Monitoring**—Reports used to track what is happening within the business, for both front-end and back-end reporting.
- (26) **Finance**—Tools used to estimate and provide for losses, and others that allow lenders to focus upon profitability, including the use of risk-based pricing.

Chapter 23 looks at scorecard *implementation*, both: (i) decision automation—high-level considerations (especially for greenfield developments), relating to the level of automation, responsibility, employee communications, and customer education (including decline reasons and the appeals process) and (ii) implementation and testing—including data, resources, and migration issues, and testing ‘actual versus expected’ for scorecard and strategy parameters, and for operational drift.

Credit scoring is not perfect, and issues may arise because of rare but severe events, data evolution, and known scorecard weaknesses—especially when there is information not captured by the system. *Chapter 24* looks at *overrides, referrals, and controls*: (i) policy rules—and instances where rules should be used instead of scores; (ii) overrides—subjective intervention, both high- and low-score; (iii) referrals—verification (documentation/security procedures, fraud suspicion triggers, account conditions); and (iv) controls—including the playing field (risks that may arise, and tools that can be used to protect against them), and scorecard/strategy and override controls.

A control that receives separate treatment is *monitoring*, covered in *Chapter 25*: (i) portfolio analysis—including delinquency distribution and transition matrix reports; (ii) performance tracking—scorecard performance, vintage/cohort analysis (and new-account, life-cycle, and portfolio effects), and score misalignment reports; (iii) drift reporting—including population

stability, score shifts, and characteristic analysis by booking rates; (iv) selection process—decision process (track applications through the process), score distribution by system or final decision, policy rules (and how they have affected the decision), and manual overrides (by reason code and by their influence on the final decision).

Finally, *Chapter 26* covers reports required by the *finance* function: (i) loss provisioning—the distinction between general and specific provisions, and types of approaches; (ii) direct estimation—using the net-flow method or transition matrices; (iii) component approaches—which split the problem into loss probability and loss severity; (iv) scoring for profit—including profit drivers, profit-based cut-offs, and profit modelling approaches; and (v) risk-based pricing—mechanics and implementation, behavioural changes, strategic issues, and how it affects customers (especially higher-risk borrowers' increased use of home loans to finance consumption).

For those familiar with scoring, it might seem as though strategy setting has been overlooked. The basics are covered in Module A (Section 3.2.1, Process and Strategy) and Module B (Chapter 5, Decision Science), while this module covers some of the more sophisticated approaches (Section 26.4, Scoring for Profit; and Section 26.5, Risk-Based Pricing).

Module G Credit risk management cycle

When written in Chinese the word crisis is composed to two characters. One represents danger, and the other represents opportunity.

John F. Kennedy (1917–1963)

Companies evolve, so it is no surprise that the terms ‘organism’ and ‘organisation’ have the same root. The concepts differ, only in that one is the product of nature, and the other the product of men. Organisms have to worry about nourishment, reproduction, and predators, while organisations must compete for resources, attract customers, and control a myriad of risks. This applies to all ‘for profit’ entities (and others), including banks, finance houses, credit card issuers, retailers, and other consumer-credit providers. These companies are unique though, in that there are well-defined stages, collectively referred to as the credit risk management cycle (CRMC), where risks peculiar to the industry are managed. Essentially, this is an account management cycle, from the day it is a glimmer in the lender’s eye, until it passes through to its grave. In the 1960s, scoring was associated with just one part of this cycle (new-business application processing), but it is now being applied throughout.

The CRMC is not to be confused with other concepts related to the economic cycle: (i) ‘credit cycle’, the expansion and contraction of credit and (ii) the ‘credit risk cycle’, changes in overall credit quality.

Before these stages are considered, a brief review of basic marketing is in order. Textbooks put forward basic frameworks, like the marketing mix, or 5 ‘P’s, which can be used to define any market offering:

Product—The good or service being offered.

Package—Product presentation, including packaging materials and labelling.

Price—Positioning, in terms of luxury, mass, or somewhere in between.

Promotion—Communications, to prompt the product’s purchase by the market.

Place—Distribution channel(s), used to deliver the product.

The framework is general, and applies primarily to consumer goods, such as toothpaste, automobiles, perfumes, or fashion denims. The goods on offer are picked off the shelf, and paid for at the checkout counter, no questions asked. If the buyer instead wants to ‘buy now, pay later’, there are other risks, other processes, other costs, and other questions that must be asked. These may vary, depending upon whether lending is the company’s primary business (bank, finance house, or card issuer), or a secondary activity used to support sales (retailer, motor

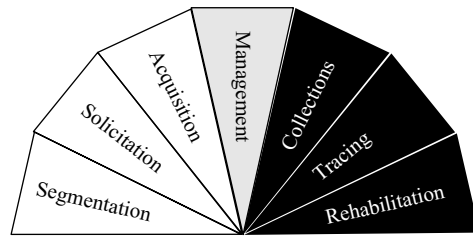


Figure G.1. Credit risk management cycle.

dealer/manufacturer, utility or service provider). In either case, providing credit adds another dimension—a cycle that also has promotion and distribution aspects, but extends further into an ongoing service relationship dedicated to the money, as opposed to what is being purchased.

For retail credit, McNab and Wynn (2003)¹ split the CRMC into five stages: marketing, application processing, account management, collections, and recoveries. Marketing and recoveries can be further split to create seven operations, as shown in Figure G.1.

Segmentation—Identifies customers to be targeted, their needs, and appropriate products.

Solicitation—Designs and executes marketing campaigns, used to invite potential customers to do business.

Acquisition—New-business processing, which obtains and processes applications, delivers the goods if they are accepted, and handles communications and queries if not.

Management—Functions required during normal account operations, especially limit management, but also handling repayments, billing, queries, billing, and others.

Collections—Focuses on early-stage delinquencies, and on maintaining the customer relationship.

Tracing—Attempts to find and contact absconders, who move without providing a change of address or other contact details.

Rehabilitation—Deals with late-stage delinquencies, to get the money back (or as much as possible), which may lead to legal action and/or loss of the customer relationship.

In corporate credit, risk transfer is treated as a separate stage. In retail credit, it is done at portfolio level, and could be done as part of account acquisition, management, collections, or recoveries, whether through insurance, securitisation, hedging, or outright sale of assets.

Credit risk management function

All of the decisions made during the CRMC have an impact upon risk, and many lenders will have a specialist area that works with various business units to manage it. This *'credit risk*

¹ This section is borrows heavily from McNab and Wynn (2000 and 2003), and from associations with Helen McNab and Scoreplus Ltd.

management’ area would perform functions like (i) working with *marketing* on setting eligibility criteria for new products (whether for through-the-door or pre-approved customers), identification of prospective customers, new product pricing, package eligibility, and so on; (ii) setting *new business strategies*, and policies for application processing—including cut-offs and limits, pricing, and repayment terms at different levels of risk; (iii) setting *account-management strategies*, for limit increases and authorisations; and (iv) setting *collections policies and strategies*. It may also provide a *decision support* function and ‘decision tools’—the models and software required to calculate scores and apply strategies and policies, as well as monitor what happens, and make changes as required.

Other business functions

While not directly related to credit risk management, there are several other areas with which the credit function must interact:

Compliance/legal—Ensures that no laws, statutes, or regulations are broken. This is particularly important in areas of illegal discrimination, data protection, and ‘know your customer’ legislation.

IT/systems—Ensures the smooth operation of mainframe and networked computers, and communications used to perform functions across the business. At one time, the risk management and other functions were highly dependent upon them, but this changed as computers became cheaper and smaller—minis, PCs, notebooks, etc.

Management information—Required to manage and understand customer behaviour, and to report information from across the organisation to the company executive, and others. This may be a part of the IT function, but most companies have split it off separately.

Accounting, finance, planning, and audit—Other functions within the company that are responsible for accounting, understanding profitability, setting high-level strategies, and ensuring that the results are understood.

The matrix

The CRMC is widely referred to within the retail lending industry. Indeed, it applies to almost any credit product or market, and is used as a conceptual framework when positioning discussions about problem areas within the business, especially when combined with the key process components: (i) *data*—for analysis, modelling, and reporting; (ii) *systems*—for gathering data and delivering products and decisions; (iii) *models*—for representing risk, revenue, retention, and response; (iv) *strategy*—for rule-sets that leverage upon data, by using models and policies to drive decision-making; (v) *analytics*—for manual review of summary statistics to turn data into knowledge; and (vi) *reporting*—for monitoring results to ensure that all runs

Table G.1. CRMC versus process components—discussion matrix

Function	Component					
	Data	Systems	Models	Strategy	Analytics	Reporting
Marketing						
Application processing						
Account management					✓	
Collections						
Recoveries						

according to plan. This is by no means the full set; there are entire departments whose names could be listed across the top. Two others that have a direct interest in risk are

Fraud—Prevents fraud when it can; identifies fraud when it happens; and brings in the law enforcement agencies when necessary.

Risk management—Considers all risks, where credit risk is only one of them. Ultimately, business targets must be met, while keeping risks at acceptable levels.

These are then presented in a matrix, such as that in Table G.1., which indicates an analytics issue in account management.

This module

The above section provided a broad overview of many functions that must be performed by any credit provider. The module itself is split out into five sections, each of which gives certain aspects of the CRMC individual treatment, in particular,

- (27) **Marketing**—Advertising media, quality versus quantity, pre-screening, and data used.
- (28) **Application processing**—Operations of selection processes: gather, sort, and action.
- (29) **Account management**—Takers, askers, givers, repeaters, and leavers.
- (30) **Collections and recoveries**—Default reasons and recovery processes, triggers and strategies.
- (31) **Fraud**—Trends, types, and tools.

All of these are becoming increasingly dependent upon statistically derived models, and decision automation, to drive their business processes. Fraud is really an operational risk, which does not really belong in this group, but must be considered across the CRMC.

Marketing is the tout responsible for identifying and attracting prospective customers, which is covered in *Chapter 27*: (i) advertising media—which can be defined as broad-based or personal, or as print, tele-, cyber, or person-to-person, with a focus on maximising the ‘bang

per buck'; (ii) quantity versus quality—a conflict that arises between marketing as credit, and which affects processes' ability to cope; (iii) pre-screening—which involves list scrubbing and use of other metrics to target customers (the 4 Rs); and (iv) data—including types of data, and its assembly into a data mart.

Application processing is the gatekeeper for through-the-door customers, covered in *Chapter 28*. It is treated using headings that would apply to any selection process: (i) gather—acquisition and preparation of completed forms; (ii) sort—obtain the necessary information, use it to provide an assessment, and then make a decision; (iii) action—communicate the decision and carry out the required actions, and exploit opportunities for up-sells, down-sells, cross-sells, approval in principle, and credit insurance.

Chapter 29 moves on to *account management*, the bartender who ensures existing customers' needs are served. While it includes a range of functions, including billing and payment processing, here it relates primarily to limit management: (i) types of limits—agreed, shadow, and target limits (along with brief mention of debt counselling services relating to cash-flow triage); (ii) over-limit management—to deal with those who take without asking, including pay/no pay decisions for cheque accounts and authorisations for credit cards, and the informed customer effect (customers facing equally bad choices will choose that which is best understood); and (iv) more limit and other functions—including limit increase requests, limit increase campaigns, limit reviews, cross-sales, and win-back campaigns.

Collections and recoveries are the heavies, who deal with problematic customers and guard the back door. Collections play the good cop, who tries to put the customer on the right track. In contrast, recoveries play the bad cop, whose only interest is in getting the money back. *Chapter 30* is split into (i) overview—delinquency reasons, underlying processes, core system requirements, and agencies; (ii) triggers and strategies—where triggers include excesses, missed payments, and dishonours, and strategies can vary by message tone, content, delivery, timing, and extent; (iii) scoring—special issues relating to definitions, time frames, and usage.

Finally, *Chapter 31* looks at *fraud*, the town detective who deals with cheating customers. This area has always been challenging, and modern technology is making it even more so. After highlighting fraud trends, the chapter moves on to (i) fraud types—split by product, relationship (first-, second-, or third-party), process (application, transaction), timing (short or long term), misrepresentation (embellishment, identify theft, fabrication), acquisition (lost or stolen, not received, skimming), usage (counterfeit, not present, altered), and technology (ATM, Internet); (ii) detection tools—negative files, shared databases, rule-based verification, scoring, and pattern detection; (iii) prevention strategies—for the application process, transaction media, and account management; and (iv) scoring—its usage for both application and transaction fraud. Of particular note, is that fraudsters' *modus operandi* are quick to counter lenders' moves, and to seek and exploit new opportunities. In recent years, this has been best evidenced by the growth of card-not-present fraud, especially for Internet transactions.

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Module H Regulatory environment

The years since the 1960s have been characterised by increasing regulation of financial institutions. This has impacted on credit scoring, either promoting it or controlling its use. This module looks at the various types of legislation, and their impact. Rather than covering the legal environment in one particular country though, the goal is to provide a framework, or frameworks, within which the regulations can be analysed.

The module is split out into six sections, a conceptual overview followed by five separate sections each covering a regulatory pillar that directly affects the provision of consumer credit, and the use of credit scoring:

- (32) **Regulatory concepts**—Best practice, good governance, business ethics, social responsibility, and the compliance hierarchy of statutes, legal precedents, industry codes, policies and procedures, and unwritten codes.
- (33) **Anti-discrimination**—Covers what information may be used in a lending decision, and prohibits the use of fields that are discriminatory (race, religion, etc.), or any information relating to parties other than the prospective borrower.
- (34) **Fair lending**—Ensures that lenders take adequate steps, to ensure that borrowers can afford the loan repayments, and that the terms are fair in the circumstances.
- (35) **Data privacy**—Governs the sharing of data between lenders, what may be kept on credit bureau, what must be divulged to customers, and so on.
- (36) **Capital adequacy**—Focuses primarily on the New Basel Accord for banks, which allows the use of their own internal ratings to calculate reserve requirements.
- (37) **Know your customer**—Increased personal identification requirements, primarily to prevent money laundering and criminal activities, but also terrorist activities.
- (38) **National differences**—An overview of some of the laws in force within various English-speaking countries, in particular the United States, United Kingdom, Australia, Canada, and South Africa.

The module's starting point is some *basic concepts*, presented in *Chapter 32*: (i) best practice—ways of doing things that have a proven record of success; (ii) corporate good governance—limit the executive's power, and ensure transparency; (iii) business ethics and social responsibility—act according to what is right or wrong, respect other stakeholders, and give back to those being served; (v) the compliance hierarchy—including statutes, legal precedents, industry codes, policies and procedures, and unwritten codes.

Lenders depend upon data for their risk assessment, which presents a power imbalance that can be abused, and *data privacy* issues. These are covered in *Chapter 33*, which covers: (i) background—including a historical overview covering the Tournier case of 1924, OECD

data privacy guidelines, the Council of Europe convention, and the EU data protection directive; (ii) data privacy principles—relating to the manner of collection, reasonable data, data quality, use of data, disclosure to third parties, subjects' rights, and data security.

Credit scoring is used to discriminate between potentially good and bad business, which can lead to claims of unfair discrimination. *Chapter 34* covers *anti-discrimination* legislation, including (i) what does it mean?—which provides different views on what is acceptable, from 'credit scoring is unfair' through to 'most characteristics can be used, as long as they form part of a holistic assessment, and there are no reasonable alternatives' and (ii) problematic characteristics—where treatment varies, including age, gender, marital status, government assistance, and unlisted phone numbers.

In general, credit scoring promotes *fair lending*, but it can be abused. *Chapter 35* illustrates the distinction between: (i) predatory lending—which victimises borrowers for the personal gain of the lender; (ii) irresponsible lending—practices that involve questionable ethics and fail to consider the effect of debt on borrowers; and (iii) responsible lending—acting in the best interest of borrowers, including conducting due diligence, aiming for financial inclusion, ensuring transparency, and educating customers. Responsible lending is obviously the ideal, and while most countries have legislation to guard against predatory lending, the treatment of irresponsible lending is mixed.

On the good governance front, credit scoring has also become a cornerstone of determining banks' *capital adequacy* requirements for retail credit risk. *Chapter 36* provides a historical overview, and then covers: (i) Basel I—implemented in 1988, which set simple requirements for sovereign, bank, residential property, and other lending; (ii) the new Basel accord—which allows a similar standardised approach, but most affected banks are instead opting for the foundation and advanced 'internal ratings based' approaches; and (iii) the risk-weighted asset calculation—based on Merton's model, it uses internal ratings and within-portfolio correlations to derive a capital requirement, that is then adjusted for factors such as size, maturity, future margin income, and double default.

Something for which credit scoring is neither a regulatory target nor a tool is *Know Your Customer* legislation, which is intended to guard against criminal activities. This is the focus of *Chapter 37*, which defines racketeering, organised crime, and money laundering, before covering due diligence requirements—with respect to customer acceptance policy, customer identification, treatment of high-risk accounts, and day-to-day identification of abnormal transactions.

Although most English-speaking countries are surprisingly similar in this domain, there are some notable differences. *Chapter 38* briefly discusses the situations in (i) the United States—the Fair Credit Reporting Act (1970) and Equal Credit Opportunity Act (1974); (ii) Canada—privacy (especially Quebec's Bill 68) and human rights legislation; (iii) the United Kingdom—the Consumer Credit Act (1974) and Data Privacy Act (1984/1988); (iv) Australia—Privacy Act (1988) and Privacy Amendment Act (2000); and (v) South Africa—National Credit Act (2006). Other pieces of legislation in each country are also mentioned. The major credit bureau and personal identifiers used in each are also discussed.

Finally

Enjoy the book.

This book is based on an extensive literature review, and is naturally influenced by the author's interpretations and own experience. While every effort has been made to ensure accuracy, please do not hesitate to submit any queries, suggestions or corrections relating to the text to the author or publisher.

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