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MODELING AND SIMULATION OF CONSUMER CREDIT ORIGINATIONS PROCESSES

Hung-Nan Chen
Jihong Jin
Geetha Rajavelu
Charles Reichenbach

Consumer Credit Group
Wells Fargo Bank
11601 N. Black Canyon Highway
Phoenix, AZ 85029, U.S.A.

ABSTRACT

Staffing decisions in a consumer credit origination environment have a significant impact on the financial institution's costs as well as customer service levels. Staff resources account for a substantial portion of the expenses in processing and servicing home equity or consumer loans. This paper describes a staffing model, known as the Capacity Planning Simulation Model (CPSM), used in the Originations Division of Wells Fargo Bank's Consumer Credit Group. The CPSM utilizes process mapping, spreadsheet modeling, and Monte Carlo simulation to model demand uncertainty and process variation, observed during the course of processing a consumer credit loan. We review the model formulation, verification, validation, and application.

1 INTRODUCTION

Wells Fargo's Consumer Credit Group, CCG, has experienced substantial growth in recent years. Since 2000, CCG expanded from a single home equity channel to four separate business lines, including Regional Banking, Equity Direct, Direct-to-Consumer, and Personal Credit Management, collectively manned now by nearly 2400 production team members. The Group offers an increasingly diverse selection of consumer credit products that meet the individual needs of many different types of customers. Though difficult to predict, demand for these financial products has been very strong across CCG's markets; the number of applications for home equity products, alone, has almost tripled in the past three years.

CCG's remarkable growth has presented several challenges. Within the Originations Division, finding practical solutions to (1) forecasting the demand for our consumer loan products, (2) determining optimal staffing levels, and (3) minimizing the inherent process variation in our originations, processing, and servicing operations are of keen interest to CCG's finance and operations managers.

Staffing is one of the Group's key planning activities. It directly drives salary expense, which is a major piece in many financial institutions' cost structure. It also drives facility planning, training, benefits, and many other related costs. More importantly, it strongly correlates with service quality a financial institution provides to its customers. The tradeoff between providing best customer service and keeping its cost down has been an art of balance and one of the key factors that determine if a company in the industry will survive.

Prior to 2003, CCG relied on deterministic spreadsheet-based models to quantify production staff, or FTE (full-time equivalent), and resource expenses, e.g. physical space, systems, etc. Operating budgets were developed with output from these models that typically used general "applications per FTE" productivity factors. However, as the business evolved, offering more and more diverse products across multiple channels in an uncertain environment, the simple spreadsheet staffing models no longer offered the capability necessary to support increasingly complex decision-making. Furthermore, the models' FTE predictions were inaccurate and ill-suited to the needs of the organization; operations managers requested more detailed plans, including FTE staffing plans by operating center, by product, by marketing division, by marketing region, by functional group, by accounting unit (AU), and even by task. Along with more comprehensive reporting, managers really needed to know the staffing levels that were most probable, not merely those that were possible (Decisioneering 2001). The former spreadsheet model was obsolete, in part because it suffered from "the flaw of averages" (Savage 2002); it was based on calculations using average values, completely ignoring the uncertainty of the application forecasts and the variability associated with CCG's consumer credit originations processes.

To support exponential growth in an increasingly competitive and complex business environment, CCG developed a dynamic resource planning model called the Capacity Planning Simulation Model (CPSM). We use the CPSM to-

day to determine optimal resource plans such that we maximize productivity, minimize cost, and satisfy key service quality metrics. This paper reviews the design and implementation of the CPSM, created and developed by the members of the Capacity Planning Team (CPT) within the Finance Department, Originations Division of CCG. The CPSM was conceived to address the shortcomings of the former staff planning spreadsheets. The implemented model has not only met the organization's needs on staff planning but also provided many benefits that other groups within the company have enjoyed.

The rest of this paper is organized as follows. In section 2, we briefly describe the typical loan application processes. The existing staffing model is described and the characteristics of a desired staffing model are identified. We then present our modeling approach in section 3. Detail of verification and validation of the model is given in section 4. In section 5, we discuss how the model is implemented and utilized in our monthly, quarter, and annual planning activities. Section 6 concludes this paper and gives future research directions.

2 CONSUMER CREDIT ORIGINATION PROCESS DESCRIPTION

Wells Fargo's consumer credit business has several channels—Regional Banking, Internet, Telesales, Phone Bank, Equity Direct, and Personal Credit Management. Much of the Group's business is a direct result of its relationship with many Home Mortgage Consultants, bankers, and other sales professionals in Wells Fargo Home Mortgage. A consumer credit application can be a home-equity loan, a home-equity line of credit, or a personal property loan or line or credit. A simplistic representation of a loan originations process is depicted below in Figure 1.

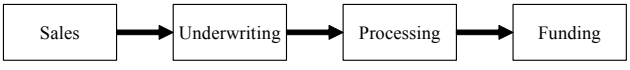

Figure 1: The Consumer Loan Originations Process

The process starts with Sales, whereby applications are accepted and entered into the system. In the Underwriting step, applications are reviewed and an initial decision is rendered, usually contingent on verification of the applicant's credit score, loan-to-value ratio (LTV), income, assets, appraisal value, and other factors regulated by fair-lending practices. At this step, an application may be turned down with cause, countered, or approved and then advanced to the processing step. Specialists in Processing identify stipulations, clear them, and schedule a closing date. In the Funding step, closing documents are prepared, sent to the applicant(s), signed and returned from the applicant(s). Funds are then disbursed to the applicant(s) either by check or wire, and documents are forwarded to Consumer Loan Servicing.

To make a staffing decision for such a process, the following questions must be answered.

1. How many distinctive processes are involved?
2. For each process, what tasks need to be performed, when do they need to be completed, and how often?
3. What is the time required to perform each task? Can the task times vary, and if so, how much?
4. What is the number of applications expected to be processed at each step?
5. What are the required training, skill sets, and availability of the loan processors?

These questions are not trivial. Loan originations processes still require considerable manual effort; consequently, many of these questions are hard to answer. An example is the "initial decision" where, based on the loan amount, customer's credit status, the appraised value of the lien, and many other factors, this step may take from just a few minutes to several days to complete if multiple iterations are involved. Another example is the difficulty associated with determining the expected number of applications to be processed at each step. This number may in fact differ depending on where the application came from as well as the timing (month of year) when the application is received. This implies that geographical differentiation and seasonality can affect the normal processing characteristics.

A lot of statistical analyses have been performed on marketing forecast, approval rates, process variation, and credit policies, all of which play equally important roles in forecasting staffing requirements. After all, the staffing model must predict how many FTEs are required to support a given volume forecast. The quality of the FTE forecast, however, is heavily dependent upon the above mentioned studies. Without accurate knowledge of the approval rates at the regional level, for example, a model may predict the FTE requirement relatively accurately at the summary level, e.g. for the marketing division as a whole, but fail to predict FTE requirements accurately at the lower regional levels. For all channels, the regional FTE forecasts are very important. For without reliable FTE numbers at the regional level, managers can not fully explore workload leveling strategies, innovative work sharing practices, and other operating strategies. Therefore, it is critical that the aforementioned statistical studies have been performed to support a robust staffing model.

A staffing model is essentially a capacity model, where the required FTE is calculated by simply dividing the required labor hours by the available labor hours.

$$\text{FTE} = \frac{\text{Required Labor Hours}}{\text{Available Labor Hours}} \qquad (1)$$

"Required Labor Hours" is a function of the expected number of applications for a period (month, for example), number of tasks to be performed for each application, number of times each task is completed, and the time required to perform each task in hours. Similarly, the "Available Labor Hours" is a function of the expected hours a full-time equivalent production team member, e.g. underwriter, processor, or funding specialist, will perform his or her designated tasks in the same period (again, month, for example). CCG's policies pertaining to paid time off (PTO), scheduled work breaks, meetings, and job training influence how much non-productive time is excluded from the Available Labor Hours.

A staffing model involving simple formulae as this can be easily implemented in a spreadsheet. However, when uncertainty and variability are considered, special attention needs to be paid. In the following section, we present our approach, where a commercially available software package, Crystal Ball (Decisioneering 2001), is used to model uncertainty and variability within the consumer credit application processes.

3 SIMULATION MODEL

The goals of our staffing model are to: (1) provide operations managers with timely and accurate staffing requirements to support not only the development of the monthly, quarterly, and annual budgets, but also to facilitate tactical decision-making; (2) enable users to efficiently analyze complex what-if scenarios, yielding insight into alternative business growth strategies; (3) allow users to quantify risk levels corresponding to different staffing plans, subject to variation in CCG's originations process and uncertainty associated with application volume forecasts; and (4) provide the CCG executive team with division-wide resource plans in a convenient format. With these goals in mind, the Capacity Planning Team (CPT) has defined an architecture that complements CCG's "Customer Centric Organization" structure and also allows for highly flexible and expeditious model building within a standard platform, applicable across all CCG business channels. The model is called the Capacity Planning Simulation Model (CPSM) and its architecture is shown in Figure 2.

The main elements of CPSM's architecture are defined below.

Product Templates: the core process model with all task-level definitions and assumptions (see below) for volume-driven FTE. **Volume drivers**, a class of assumptions within the product template, are analogous with major stages or "milestones" that applications may achieve during the process. The percentage of applications that meet a given volume driver is called the yield rate, pull-through rate, or **"waterfall" rate**, or WFR. Initial Approvals is oneexample of a volume driver that could have a corresponding WFR of 80%. This rate is used as a means of estimating how many applications need to be processed at a given step, and therefore, determines how many times each task needs to be performed and, ultimately, how many FTEs are required for that specific step. **Pipelines** reflect the timing of an application to reach each process step (task). In other words, it simulates the queuing of work being accumulated at certain steps. Shown in Table 1 is an example of "waterfall" rates.

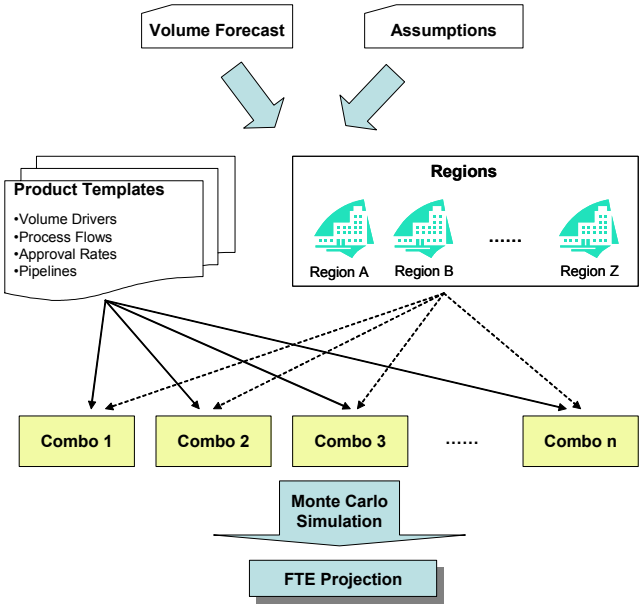

Figure 2: CPSM Architecture

Table 1: "Waterfall Rate" Example

Volume Driver	Incremental Waterfall Rate	Cumulative Waterfall Rate
Application	100%	100%
Initial Approval	85%	85%
Final Approval	**90%**	**76.5%**
Funding	90%	68.9%

In the above example, 90% of "Incremental Waterfall Rate" for the volume driver Final Approval means that 90% of "initially approved" applications will "finally be approved" – which is equivalent to say that 76.5% of total application will finally be approved.

Regions (or Market Regions): geographical segmentation defining where applications are originated from. The "yields" or "pull through rates" for different regions may be significantly different. . Note that regions "roll-up" into divisions; typically, multiple regions fall within a given division and a region is assigned to one and only one division.

Volume Forecast: the forecasted number of consumer credit applications, summarized by period (month or week), by product type, by region. The forecast is specified with a statistical distribution.

Assumptions: define the values of base assumptions by period, by product, and by region. The reason that these values may change is because of planned improvement projects (which may reduce the FTE requirement) or possible risks (which may increase the FTE requirement) along the whole planning horizon (see Scenarios).

Combos: a combo is the joining of a product template and those regions from which applications will be "run through" the selected product template. Using combos, users may dynamically model any combination of processing centers, products, and regions.

Scenarios: a scenario includes all the combos associated with a product template-region combination(s). A scenario usually includes revised assumptions reflecting improvements, process changes, or operational risks to be modeled.

Monte Carlo simulation: using Crystal Ball software (Decisioneering 2001), volume forecast and task times (the duration required for an FTE to perform a task) are defined as Crystal Ball assumptions whose values are specified with statistical distributions and their corresponding parameters. For example, the task time for a task may be triangularly distributed with minimum 10 minutes, maximum 45 minutes, and most likely, 15 minutes. During simulation, Crystal Ball generates random samples for each Crystal Ball assumption based on the specified statistical parameters. In our case, FTE is the desired output. Hence, FTE numbers calculated for each of the many tasks in the product templates are Crystal Ball forecasts for which statistics will be collected and reported. Recall that the FTE calculation is basically Required Labor Hours divided by Available Labor Hours. When Monte Carlo simulation is applied, the basic FTE formula is as illustrated in Figure 3.

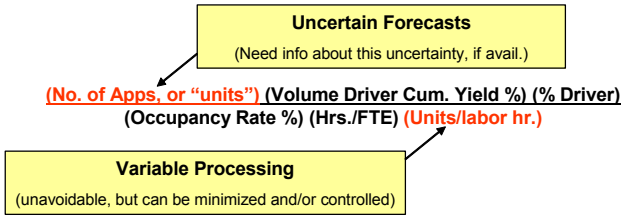

Figure 3: FTE Calculation with Forecast Uncertainty and Process Variation

A typical CPSM analysis will involve the construction of a series of "scenarios" each consists of a number of combos. For each combo, a product template is selected and a number of regions are defined. The assumptions need to be modified to reflect any possible FTE reduction or increment throughout the planning horizon (usually 12-18 months). Upon completion of the CPSM model run, output is generated in a database file, available for further analysis or budget planning, and then uploaded to a secure online Microsoft Excel pivot table (Microsoft 2004) report.

4 MODEL VERIFICATION AND VALIDATION

The CPSM is implemented in Microsoft VBA for Excel (Microsoft 2004). We employed the following verification and validation techniques.

4.1 Verification

During the construction of product templates, subject experts were interviewed to verify that all assumptions are correctly entered. Where possible, we studied sets of empirical data, sample data, and cross-referenced other quantitative metrics to ensure accuracy. Subject experts are comprised of production managers and supervisors and are identified both horizontally (by geographical locations) and vertically (by process functions). Excel formulae were tested extensively to confirm the correct calculation of FTEs. VBA programs were also tested to ensure that the behavior of the program is as expected and stable under operating conditions.

4.2 Validation

CPSM predicted FTEs were compared to the actual FTE during the validation process. The FTE prediction was first compared at the macro level and then gradually drilled down to functional level and also at the geographical level. During the validation process, some assumptions may need to be adjusted and all functional and geographical representatives have to agree on the adjustments. Validation is an ongoing process, requiring maintenance. We have used Crystal Ball's sensitivity analysis feature (Decisioneering 2001) to expedite the validation of FTE predictions for those tasks that are most influential.

The CPSM results were also compared to the former model at the high level. Though our confidence in the former model was dubious, at best, it offered a reference point for model calibration. Recall that CPSM provides more detailed FTE forecast, therefore only high level comparisons were possible. Again, during the validation phase, some assumptions may need to be adjusted and would require approval by key stakeholders, after the change(s) is, in fact, validated.

After these processes, the CPSM was considered verified and validated, ready for the forthcoming forecasting season. Resource plans (i.e. monthly, quarterly, and annual budgets) for all CCG Originations Division business channels are now based on results of the CPSM.

5 APPLICATIONS AND DISCUSSION

The CPSM was implemented and deployed in 2003 and has been used for the organization's monthly, quarterly, and annual staff planning activities. The model provides timely and accurate staffing requirement based on the vol-

ume forecast and planning assumptions. Shown in Figure 4 is a screen shot of executing the system for one of business channels of the organization.

In the figure, the screen "Define Scenarios" shows that two scenarios have been defined and the first scenario is currently been edited. The "Define Combo" screen shows that there are seven combos defined and the combo "Simo" is currently been edited. The top screen "Edit Combo" shows that multiple regions (Mid-Atlantic 5, 12, 91, etc.) have been selected for the product "Simo" and that there are functions (such as "Change Volume" and "Change Volume Driver and %") that allow detailed assumption change for the model.

Once the scenarios and combos are completed the CPSM can be executed. The output from the CPSM is a sheet called "DB_Output" where the projected FTE requirements are calculated and shown by product, by function, by period, and to the level of regional details. The "DB_Output" sheet is then imported to a business-specific template for producing a report that satisfies the requirements for the corresponding business. Typically, a set of predefined "standard reports" as well as a pivot table are provided. The standard reports provided the FTE projection in a pre-defined format that most finance managers and production managers will find useful. They also serve as the controlled and official projection for the business. On the other hand, the pivot table report provides all the details a manager may want to see. The manager may choose his/her choices of details to show the FTE projection.

The general feedback from the users of CPSM are very positive. The most favored features of the CPSM are:

1. It complies with the organizational business model.
2. It provides the FTE projection in the desired format.
3. The modeling of the assumptions, specifically, the scenario-combo structure, allows flexible and controlled assumption changes.
4. It provides the analysis and level of details that the former model can not provide.

Some suggestions from the users are:

1. The user interface needs to be improved. Many operations managers have requested access to the CPSM in order to evaluate ad hoc capacity analyses.

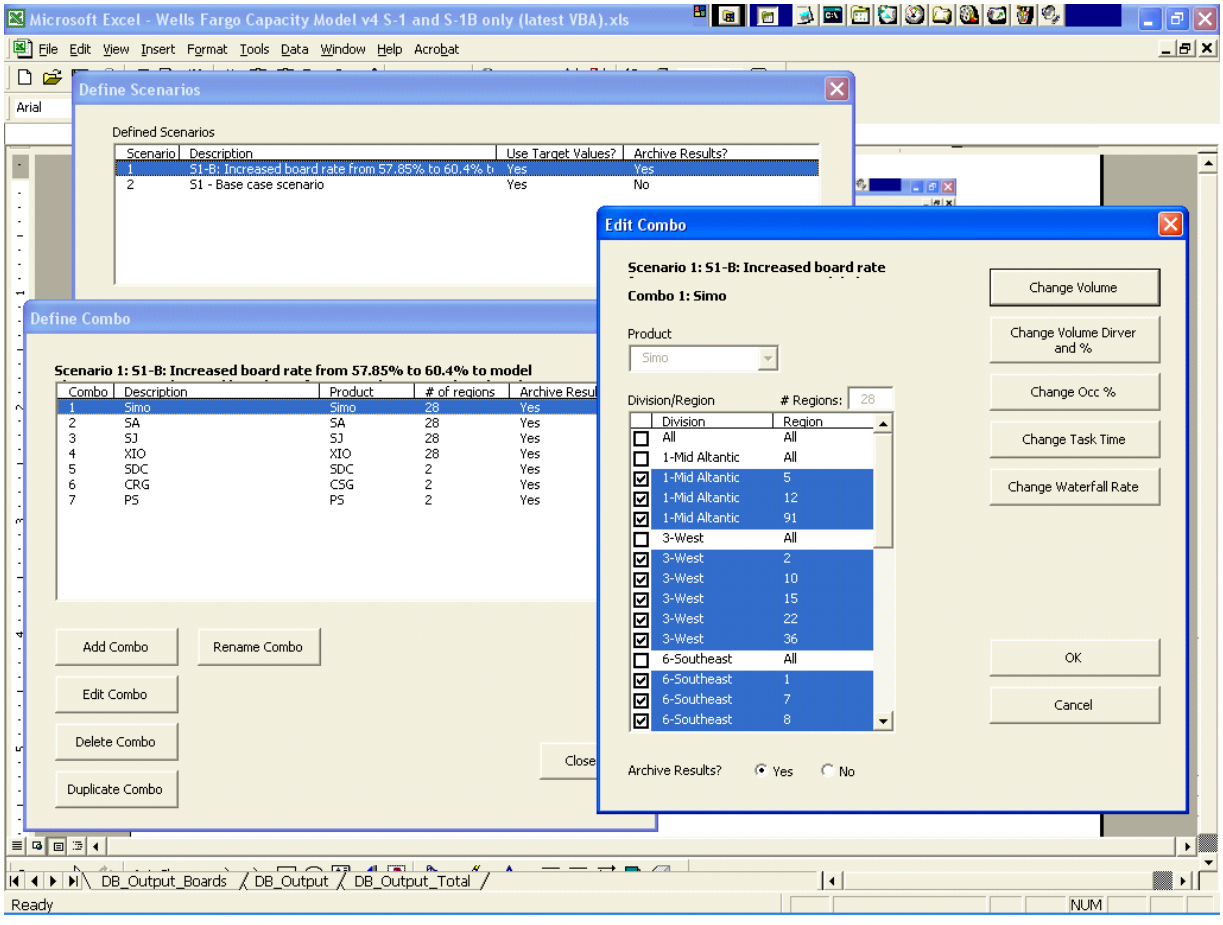

Figure 4: CPSM Screen Shot

2. The communication and control of changes to the CPSM needs to be improved.
3. Execution time needs to be reduced.

These feedbacks have provided valuable information as to which direction the CPSM will evolve to. A "Graphical User Interface" (GUI) project is already underway to improve the user interface so that CPSM is not only accessible to the capacity planning team but also available to operations managers who might be interested in running what-if analyses regarding FTE prediction. A formal "capacity planning" forum has been established to review model assumptions and any outstanding issues on a regular basis.

6 CONCLUSIONS AND FUTURE WORK

This paper has presented a capacity planning simulation model (CPSM) that utilizes Monte Carlo simulation technique to model volume forecast uncertainties and process variability in the context of projecting staffing requirement for a consumer credit processing organization. The system was implemented in VBA programming language and has been used to perform the organization's monthly, quarterly, and annual staff requirement analyses. The model has now become indispensable for the organization's planning activities. However, there are several limitations of the model that need to be addressed in the near future. First, a thorough correlation analysis needs to be performed. Although the product templates captured some correlation among some variables, they have been defined qualitatively rather than quantitatively. Second, optimization of FTE allocation needs to be automated. The optimization of FTE allocation across the planning horizon is still done manually and this has slowed down the whole analysis process. It is critical to automate this portion in order to reduce the analysis time and also reduce some arbitrary effect resulting from the manually optimization. Finally, discrete event simulation may be used to improve the quality of FTE prediction. Due to the fact that CPSM is still spreadsheet based, all time-relevant assumptions are approximated. For example, the pipelines were approximated by using different pre-defined percentages. Cycle time can not be estimated. Utilization of FTEs is not fully realized. By using discrete event simulation, these factors may be better understood and modeled.

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AUTHOR BIOGRAPHIES

HUNG-NAN CHEN, Ph. D. is a senior operations research analyst at Wells Fargo Bank. His specialties and research interests are Operations Research, Capacity Planning, Production Control, and Simulation. He received a Ph.D. degree in Industrial Engineering from Arizona State University. He is a Member of The American Production and Inventory Control Society (APICS), Society for Computer Simulation (SCS), and INFORMS. His e-mail address is <hung-nan.chen@wellsfargo.com>.

JIHONG JIN, Ph. D. is a senior operations research analyst at Wells Fargo Bank, and an adjunct faculty in MBA at Cardean University. Her research interests lie in applied operations research, with emphasis in stochastic models, especially the probabilistic and statistical aspects of stochastic simulation. She received her Ph.D in industrial engineering from Purdue University. Her e-mail address is <jihong.jin@wellsfargo.com>.

GEETHA RAJAVELU, Ph. D. is a senior operations analyst at Wells Fargo Bank. She has a PhD in Industrial Engineering (Quality & Reliability) from Arizona State University. Her areas of specialty include Applied Statistics, Operations Research and Project Management. She has over 8 years experience in the semiconductor, life sciences and financial services industries. She is a Six Sigma Black Belt and a certified Project Manager. Her e-mail address is <geetha.rajavelu@wellsfargo.com >.

CHARLES REICHENBACH manages Capacity and Resource Planning at Wells Fargo Bank, Consumer Credit Group. He has fifteen years of experience in operations management across various industries including banking, pharmaceutical R&D management, automotive vehicle development, electronics manufacturing, and consulting. Charles' research interests lie in applied operations research, with emphasis in strategic planning, decision analysis, resource optimization, process simulation and design, and financial modeling. He received his M.S. in Systems Engineering with concentrations in Operations Management and Operations Research from the University of Pennsylvania. His e-mail address is <charles. reichenbach@wellsfargo.com>.