

EXECUTIVE SUMMARY

Mortgage loan is a core business of banks. To ensure a profitable mortgage loan business, banks need to reduce both inefficiency in the mortgage application process and mortgage loan defaults. Machine reasoning can address both issues by automating tasks & implementing business rules from knowledge discovery.

I used the KIE suite of tools, jBPM and Drools to enhance a mortgage application process project with reduced processing time, fewer human errors, and that can identify customers who are likely to default on their loan. I added business rules tasks to (1) calculate interest rate and cutoff values for debt-to-income ratio, (2) flag out customers with high debt-to-income ratio, and (3) predict customers who are likely to default on their loan by using more predictors uncovered by knowledge discovery.

The mortgage application process was successfully implemented with the additional enhancements, and met the objectives of improving the business process and reducing mortgage loan defaults. This system can help banks generate higher profits by reducing losses and delivering better customer experience.

BUSINESS PROBLEM BACKGROUND

Mortgage loan is one of the core businesses for banks. The business of mortgage loan involves banks processing customer applications for new loan. The mortgage application process includes several tasks taken by the bank from the moment the application is received all the way to disbursement of the loan. These key tasks are:

- Application checking
- Information verification
- Loan approval decision

Banks need to address two issues to ensure a profitable mortgage loan business:

1. How to increase the efficiency of the mortgage process, and
2. How to minimise the number of mortgage loan default

Inefficiency in the mortgage application process

A well-executed mortgage application process can increase profit for the banks. However, there are common pain points to overcome to achieve an efficient mortgage process. These pain points are:

1. Manual processing of mortgage tasks causes long wait for customers
2. Human error causes loan approval decision to be made based on inaccurate information

Mortgage loan defaults

To avoid losses, banks need to identify customers who are likely to default on their loans. Banks can gain insights from their data to better identify customers at risk of default. For these knowledges to be useful to the bank, it needs to be incorporated into the mortgage application process.

Machine reasoning: Automating tasks & implementing business rules from knowledge discovery

Machine reasoning can address the issues of inefficiency in the mortgage application process and help to identify customers who are likely to default on their loans:

- Machine reasoning cuts processing time and guards against human error by replacing human tasks with automated tasks guided by business rules, and thus improving the efficiency and accuracy of the mortgage application process.
- Machine reasoning minimizes the number of defaulted loans by translating knowledge of loan default into business rules that can reason and identify customers who are likely to default on their loans.

Thus, incorporating machine reasoning in mortgage application process helps banks to stay competitive, reduces costs and delivers better customer experience. Ultimately, this will lead to greater profits for the banks.

PROJECT OBJECTIVES & SUCCESS MEASUREMENTS

The objective of this project is to create and deploy a mortgage application BPMS/BRMS system for banks to use:

1. with faster processing time and fewer human errors than a manual system, and that
2. identify customers who are likely to default on their loan

Success of the system will be measured by:

1. the replacement of human tasks by automated business tasks for application checking and information verification
2. the incorporation of machine reasoning that uses application information to identify potential customers who will default on their loans

PROJECT SOLUTION

The project will be created using the KIE suite of tools, jBPM and Drools. The sample project 'mortgage process' in KIE serves as the initial starting point to build in the enhancement for the machine reasoning mortgage application process project. This report will not describe the original components and processes that came with the sample project 'mortgage process'. Instead, I will focus on the enhancement I made to the sample project.

Business Rules Tasks

These are the seven automated business rules tasks of the mortgage application process. I enhanced the system by adding two more business rules tasks and included more predictors of loan default in the business rules task "DT Mortgage Machine Reasoning" (Fig 1). The enhancements are indicated by * asterisk.

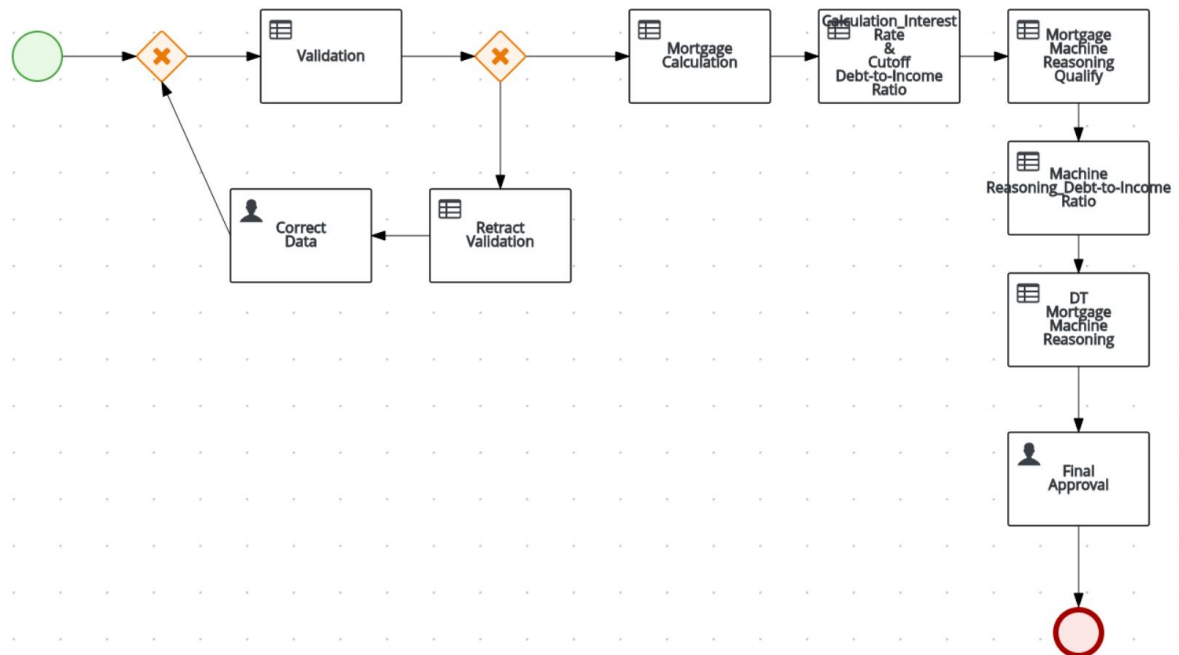
1. Validation
2. Retract Validation
3. Mortgage Calculation
4. ***Calculation_Interest Rate & Cutoff Debt-to-Income Ratio**
5. Mortgage Machine Reasoning Qualify
6. ***Machine Reasoning_Debt-to-Income Ratio**
7. ***DT Mortgage Machine Reasoning**

Human Tasks

There are two human tasks in the mortgage application process. These tasks were not replaced by automated business rules tasks because a human is needed to provide judgment and approval for these tasks (e.g., mortgage loan disbursement decision).

1. Correct Data
2. Final Approval

Fig 1. Diagram of the mortgage application process



ENHANCEMENT OF THE MACHINE REASONING MORTGAGE APPLICATION PROCESS PROJECT

To enhance the mortgage application process, I added the following assets to the mortgage application process:

1. Guided Decision Table – InterestRateCutoffDebttoIncomeRatio
2. Guided Rules - OutlimitDebttoIncomeRatio

I also modified the following data objects by adding more properties:

1. Applicant – debt & investor
2. Application – cutoffdebttoincomeratio, interestrate, & outlimitdebttoincomeratio
3. Property – condo

These new properties were added to the respective forms of the data objects and included in the FinalApproval-taskform.

ENHANCEMENT – CALCULATION INTEREST RATE & CUTOFF DEBT-TO-INCOME RATIO

This business rules task automates the calculation of:

1. Interest rate charged by the banks on the mortgage loan
2. Cutoff values indicating high debt-to-income ratio

Interest rate

Banks charge customers interest on their loan to generate a profit. To remain competitive, banks need to set their interest rate at a level that is attractive to customers and remain profitable. One way of determining the interest rate is to base it on the customer's credit ratings.

A rule of charging higher interest rate to customers with poorer credit ratings and charging lower interest rate to customers with better ratings might help the banks attract customers regardless of their credit ratings. Customers with poorer credit ratings have more difficulty securing loan so they are more willing to pay a higher interest on their loans. Customers with better credit ratings can easily secure loan so they are on the lookout for low interest loan.

Cutoff values for debt-to-income ratio

Banks need to manage loan default risk to avoid losses. One way of managing loan default risk is to look at customers' debt-to-income ratio. A high debt-to-income ratio increases the risk of defaulting; however, customers with a history of good credit ratings may still be able to repay their loans despite having a high debt-to-income ratio. Therefore, default risk might be more accurately managed by setting the cutoff values for debt-to-income ratio based on customers' credit ratings.

Adding properties to Application data object

I added interestrate and cutoffdebttoincomeratio to Application.

- Interest rate: interestrate is of the type interger
- Cutoff values for debt-to-income ratio: Cutoffdebttoincomeratio is of the type float

Guided Decision Table – InterestRateCutoffDebttoIncomeRatio

The Guided Decision Table – InterestRateCutoffDebttoIncomeRatio implements three rules for calculating (1) interest rates and (2) cutoff values for debt-to-income ratio, based on customers' credit ratings.

Rule 1 – Low credit ratings:

WHEN credit ratings ≥ 300 AND credit ratings ≤ 619 ,
THEN interest rate = 6 AND cutoff debt-to-income ratio = 0.35

Rule 2 – Moderate credit ratings:

WHEN credit ratings ≥ 620 AND credit ratings ≤ 679 ,
THEN interest rate = 5 AND cutoff debt-to-income ratio = 0.40

Rule 3 – High credit ratings:

WHEN credit ratings ≥ 680 AND credit ratings ≤ 850 ,
THEN interest rate = 4 AND cutoff debt-to-income ratio = 0.45

Displaying the interest rate and cutoff debt-to-income ratio

The calculated interest rate and the cutoff debt-to-income ratio will be displayed in the FinalApproval-taskform, so that the approver can incorporate this piece of information to decide on approving the loan.

ENHANCEMENT – MACHINE REASONING DEBT-TO-INCOME RATIO

This business rules task automates the calculation of whether customers' debt-to-income ratio exceed their cutoff values.

The business rules task – Calculation_Interest Rate & Cutoff Debt-to-Income Ratio calculates cutoff values for customers' debt-to-income ratio. Now the cutoff values will be compared against customers' debt-to-income ratio to determine whether customers have incurred too much debt. A checkbox is ticked for customers with debt-to-income ratio that exceed their cutoff values.

Adding properties to Applicant and Application data objects

I added debt to Applicant and outlimitdebttoincomeratio to Application

- Debt: debt is of the type float
- Debt-to-income ratio exceed cutoff value: outlimitdebttoincomeratio is of the type boolean

Guided Rules – OutlimitDebttoIncomeRatio

The Guided Rules – OutlimitDebttoIncomeRatio implements the rule for calculating whether customers' debt-to-income ratio exceed their cutoff values (i.e., cutoffdebttoincomeratio).

Rule – WHEN cutoffdebttoincomeratio \leq debt / annualincome,
THEN outlimitdebttoincomeratio = true

Displaying information on debt-to-income ratio that exceed cutoff values

The information on debt-to-income ratio that exceed cutoff values will be displayed as a checkbox in the FinalApproval-taskform, so that the approver can incorporate this piece of information to decide on approving the loan.

ENHANCEMENT – DT MORTGAGE MACHINE REASONING

This business rules task uses knowledge discovery to find additional predictors of loan default and add this insight to the existing list of predictors to generate new rules to identify customers who are likely to default on their loans.

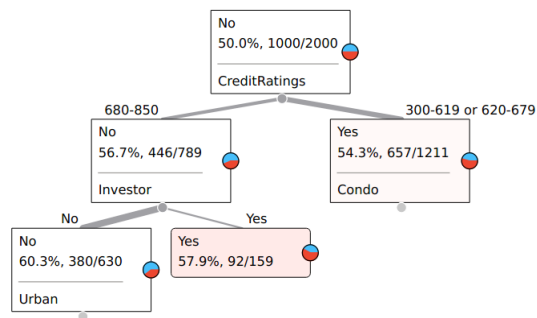
Performing decision tree analysis on loan default data

The dataset was obtained from <http://www.creditriskanalytics.net/datasets-private.html>, containing the observations for 50000 residential US mortgage borrowers. I used a random sample of 1000 loan defaulters and 1000 customers who pay off their loans to perform a decision tree analysis. I also included a subset of the predictors in my analysis to keep the scope manageable, and these predictors are:

1. Whether the property is a condominium
2. Whether the property is an urban development
3. Whether the customer is an investor borrower
4. Credit ratings

The result of the analysis uncovered three rules (Fig 2).

Fig 2. Decision tree



Rule 1 - WHEN credit ratings ≥ 680 AND credit ratings ≤ 850 AND investor = No,
THEN inlimit = No

Rule 2 - WHEN credit ratings ≥ 680 AND credit ratings ≤ 850 AND investor = Yes,
THEN inlimit = Yes

Rule 3 - WHEN credit ratings ≥ 300 AND credit ratings ≤ 679 ,
THEN inlimit = Yes

Adding properties to Applicant and Property data objects

I added investor to Applicant and condo to Property

- Investor borrower: investor is of the type boolean
- Condominium: condo is of the type boolean

Guided Decision Table – DTMortgageMachineReasoning

The Guided Decision Table – DTMortgageMachineReasoning implements 16 rules for calculating whether a customer is likely to default on his loan. These rules use the following knowledge:

1. Whether the customer own his house
2. Whether the customer has a job
3. Customer's credit rating
4. Whether the customer is an investor borrower

Each piece of knowledge has two levels (e.g., customer owns his house or doesn't own his house), and with four piece of knowledges there are 16 permutations. There are three rules that trigger the Inlimit Approval checkbox to be ticked:

Rule 1: WHEN ownHouse = true AND
hasJob = true AND
credit ratings ≥ 680 AND credit ratings ≤ 850 AND
investor = false,
THEN Inlimit Approval = true

Rule 2: WHEN ownHouse = true AND
hasJob = false AND
credit ratings ≥ 680 AND credit ratings ≤ 850 AND
investor = false,
THEN Inlimit Approval = true

Rule 3: WHEN ownHouse = false AND
hasJob = true AND
credit ratings ≥ 680 AND credit ratings ≤ 850 AND
investor = false,
THEN Inlimit Approval = true

Displaying information on Inlimit Approval

The information on Inlimit Approval will be displayed as a checkbox in the FinalApproval-taskform, so that the approver can incorporate this piece of information to decide on approving the loan.

PROJECT IMPLEMENTATION, PERFORMANCE & VALIDATION

The mortgage application process project was implemented in the KIE workbench environment, and deployed to assess its performance. Four scenarios were used to validate the new business rules for:

1. Guided Decision Table – InterestRateCutoffDebttoIncomeRatio
2. Guided Rules – OutlimitDebttoIncomeRatio
3. Guided Decision Table – DTMortgageMachineReasoning

Use/Test Case 1: Customer owns a house and has job,
credit rating = 800,
investor = false,
debt = 50000,
income = 100000

Fill in the mortgage application form as shown below (Fig 3). The business rules will perform the following tasks and display it in the FinalApproval-taskform (Fig 4):

1. Checked the Inlimit Approval checkbox
2. Checked the Outlimit Debt-to-Income Ratio checkbox
3. Display interest rate = 4
4. Display the cutoff value for debt-to-income ratio = 0.45

Fig 3. Use/Test Case 1 - Mortgage application form

MortgageApprovalProcess

Correlation key

Form

Application

Down Payment *

Years of amortization

50000

20

Applicant

Name

jacky Tan

Annual Income *

Credit Rating *

☒ Has Job *

100000

800

Debt *

☐ Investor *

☒ Own House *

50000

SSN

SSN

Property

Age of property *

☐ Condominium *

3

Address of property

25 HMKY

Locale *

Urban

Sale Price *

250000

Submit

Fig 4. Use/Test Case 1 – FinalApproval-taskform

1- Final Approval

Inputs:

Application

Mortgage amount

Interest rate

Down Payment *

☒ Default Public Income Ratio

Years of amortization

☒ Inform Mortgage Lender

Cancel Public Income Ratio

Applicant

Name

jacky Tan

Annual Income *

Credit Rating *

☒ Has Job *

100000

800

Debt *

☐ Investor *

☒ Own House *

50000

SSN

SSN

Property

Age of property *

☐ Condominium *

3

Address of property

25 HMKY

Locale *

Urban

Sale Price *

250000

Use/Test Case 2: Customer owns a house and has job,
credit rating = 800,
investor = true,
debt = 40000,
income = 100000

Fill in the mortgage application form as shown below (Fig 5). The business rules will perform the following tasks and display it in the FinalApproval-taskform (Fig 6):

1. Unchecked the Inlimit Approval checkbox
2. Unchecked the Outlimit Debt-to-Income Ratio checkbox
3. Display interest rate = 4
4. Display the cutoff value for debt-to-income ratio = 0.45

Fig 5. Use/Test Case 2 - Mortgage application form

The screenshot shows a web form titled "MortgageApprovalProcess". It is divided into three main sections: "Application", "Applicant", and "Property".

Application Section:

- Down Payment ***: Input field with value "50000".
- Years of amortization**: Input field with value "20".

Applicant Section:

- Name**: Input field with value "Jacky Tan".
- Annual Income ***: Input field with value "100000".
- Credit Rating ***: Input field with value "800".
- Has Job ***: Checked checkbox.
- Own House ***: Checked checkbox.
- Debt ***: Input field with value "40000".
- Investor ***: Checked checkbox.
- SSN**: Input field with value "SSN".

Property Section:

- Age of property ***: Input field with value "3".
- Condominium ***: Unchecked checkbox.
- Address of property**: Input field with value "25 HMKT".
- Locale ***: Input field with value "Urban".
- Sale Price ***: Input field with value "250000".

A "Submit" button is located at the bottom right of the form.

Fig 6. Use/Test Case 2 – FinalApproval-taskform

Use/Test Case 3: Customer owns a house and has job,
 credit rating = 650,
 investor = false,
 debt = 50000,
 income = 100000

Fill in the mortgage application form as shown below (Fig 7). The business rules will perform the following tasks and display it in the FinalApproval-taskform (Fig 8):

1. Unchecked the Inlimit Approval checkbox
2. Checked the Outlimit Debt-to-Income Ratio checkbox
3. Display interest rate = 5
4. Display the cutoff value for debt-to-income ratio = 0.40

Fig 7. Use/Test Case 3 - Mortgage application form

MortgageApprovalProcess

✕

▼ Correlation key

▼ Form

Application

Down Payment *

Years of amortization

50000

20

Applicant

Name

Jacky Tan

Annual Income *

Credit Rating * ⓘ

☒ Has Job * ⓘ

100000

650

☒ Own House * ⓘ

Debt * ⓘ

☐ Investor * ⓘ

50

SSN

SSN

Property

Age of property *

☐ Condominium * ⓘ

3

Address of property

25 HMKT

Locale * ⓘ

Urban

Sale Price *

250000

Submit

Fig 8. Use/Test Case 3 – FinalApproval-taskform

Use/Test Case 4: Customer owns a house and has job,
credit rating = 500,
investor = false,
debt = 50000,
income = 100000

Fill in the mortgage application form as shown below (Fig 9). The business rules will perform the following tasks and display it in the FinalApproval-taskform (Fig 10):

1. Unchecked the Inlimit Approval checkbox
2. Checked the Outlimit Debt-to-Income Ratio checkbox
3. Display interest rate = 6
4. Display the cutoff value for debt-to-income ratio = 0.35

Fig 9. Use/Test Case 4 - Mortgage application form

The screenshot shows a web form titled "MortgageApprovalProcess". It is divided into three main sections: "Application", "Applicant", and "Property".

Application Section:

- Down Payment ***: Input field with value "50000".
- Years of amortization**: Input field with value "20".

Applicant Section:

- Name**: Input field with value "Jacky Tan".
- Annual Income ***: Input field with value "100000".
- Credit Rating ***: Input field with value "500".
- Has Job ***: Checked checkbox.
- Own House ***: Checked checkbox.
- Debt ***: Input field with value "50".
- Investor ***: Unchecked checkbox.
- SSN**: Input field with value "SSN".

Property Section:

- Age of property ***: Input field with value "3".
- Condominium ***: Unchecked checkbox.
- Address of property**: Input field with value "25 HMKT".
- Locale ***: Input field with value "Urban".
- Sale Price ***: Input field with value "250000".

A blue "Submit" button is located at the bottom right of the form.

Fig 10. Use/Test Case 4 – FinalApproval-taskform

The screenshot shows a web application interface for a mortgage application process. The main content area is titled '4 - Final Approval' and contains a form with three main sections: 'Application', 'Applicant', and 'Property'. Each section has several input fields and checkboxes for data entry. The 'Application' section includes fields for 'Mortgage amount', 'Loan term', 'Loan type', 'Years of amortization', and 'Credit Rating'. The 'Applicant' section includes fields for 'Name', 'Annual income', 'Debt', 'Age', 'SSN', 'Credit Rating', and 'Debt Ratio'. The 'Property' section includes fields for 'Age of property', 'Address of property', 'Location', and 'Address'. The form is displayed in a browser window with a sidebar on the left and a top navigation bar.

PROJECT CONCLUSIONS: FINDINGS & RECOMMENDATION

The mortgage application process was successfully implemented with the additional enhancements. I met the objectives of the project which is to create and deploy a mortgage application BPMS/BRMS system for banks to use:

1. with faster processing time and fewer human errors than a manual system, and that
2. identify customers who are likely to default on their loan

The new business rules tasks performed as planned by automating application checking and information verification, and uses application information to identify potential customers who will default on their loans.

I would recommend this system for banks because it can help increase their profitability for the mortgage loan business.