

# **EXAMINATION**

May 2021

**Subject F206 – Banking  
Specialist Applications**

# **SOLUTIONS**

## QUESTION 1

GreenVest Bank (GVB) is a large South African bank that offers a full suite of Retail and Non-Retail lending products, and only operates in South Africa. The CEO of GVB has become increasingly concerned with climate change and the potential impact of this on the bank's loan portfolio.

- i) GVB's CRO has requested a report on how the bank can go about incorporating climate risk in its overall risk management. Specifically, the CRO wants the report to focus on risk segmentation, credit risk management, operational risk, and stress testing. Outline the points to be included in the report as requested by the CEO.

[6]

### Risk segmentation

- Incorporation of climate risk into risk management would require the bank to be able to identify the relevant segmentations in its portfolio and how these different segments are affected by climate risk.
- This would include the collection of additional counterparty-level climate related information, for example, geographical location of exposures.
- The next step would be to conduct an assessment of different exposures & potential vulnerability to climate risk. This would be conducted at different levels of granularity.
- Finally, the Bank would then need to consider additional segmentations by climate risk sensitive segments.

### Credit Risk Management:

- Climate risk can be considered from two different perspectives when it comes to credit risk management:
  - Firstly, from the point of view of increased default risk of counterparties due to exposure to climate risk (e.g. higher default risk due to properties being abandoned due to higher water levels).
  - Secondly, from the point of view of charging higher rates to customers from non-environmentally friendly segments and to use this to offset their own carbon emissions.
- Climate risk can therefore be incorporated in the following ways:
  - Based on data through the identification of climate risk factors and statistical relationships to risk parameters.
  - For example, the Bank can consider LGD collateral adjustments related to physical properties situated in areas susceptible to flooding or rising sea levels.

- Forward looking linkage models can be updated to allow for forecasts of climate related changes.
- Judgemental overlays to model parameters or counterparty credit ratings can be made.
- Qualitative “climate” scorecards can be developed and used as part of the rating process in order to assess whether counterparties operate in an environmentally friendly manner.

### Operational Risk Modelling

- Climate risk can also be incorporate in the Bank’s assessment of its general operational risks.
- For example, the Bank can consider extreme events modelling on damage to physical assets and business disruption impact due to flooding or rising water levels causing property damage. This may require relocation of bank assets.
- More traditional operational risk modelling:
  - Combine available internal and external data to develop a loss distribution.
  - Analysis potential mitigating actions and capital impacts on climate risk drivers.
  - Scenario and simulation analysis.

### Stress Testing

- Include climate risk scenarios as part of stress testing exercises.
- Leverage external industry analysis and literature review as there might be limited internal data.
- Derive emission adjusted sectoral macro-variables as part of the stress testing process.

ii) GVB is considering introducing climate risk into its retail IFRS 9 models. Briefly explain the key challenges of incorporating climate risk into credit risk models. [12]

### Identification of risk factors

- The first step in incorporating climate risk factors into any models would be to identify any potential / relevant climate risk factors.
- These may include rainfall, frequency of extreme weather conditions, flooding, water levels, drought.
- The bank may start with a long list of potential factors.
- This will need to be considered by portfolio. For example, a coastal mortgage portfolio is likely to be exposed to different levels of climate risk than an inland credit card portfolio.

- This may be achieved through a mixture of through judgmental or statistical methods.

#### Data Availability

- Data availability for historic climate risk factors may be limited as climate risk has only become an emerging risk in more recent years.
- In addition, portfolio data related to specific characteristics affected by climate risk (postal codes, areas) may not be available.
- There may be further challenges in consistency and reliability of the above data.

#### Model Appropriateness

- Ensuring that the credit risk models developed are appropriate, the bank will need to consider how to incorporate climate risk factors into existing models.
- This will include an assessment of:
  - The statistical significance of factors in models. Due to relatively small changes over time, and other potentially stronger factors in models (e.g. macroeconomic and behavioural such as delinquency), statistical significance may be weak.
  - Intuitiveness of variable relationships. Due to sparse data, it may be that non-intuitive relationships are identified.
  - Expert judgment may need to be used to incorporate factors in the models that may not be otherwise included on a statistical basis.
  - Compatibility with existing models. These models may be used for management purposes, or stress testing purposes, but not yet for provisioning.
  - As a result, it will be important for the Bank to be able to understand differences in models.

#### Reliability of Forecasts

- IFRS 9 requires an assessment of forward-looking expected credit losses.
- This means that climate risk factors would need to be forecasted over the lifetime of the loan portfolio, which is potentially as far out at 30 years (for Mortgage portfolios).
- In addition, portfolio factors may need to be forecast for these periods. Fortunately, for IFRS 9 purposes, only the current portfolio is provisioned for, and new business and changing dynamics (e.g. moving house) would not be included.
- This may however be required for other strategic planning purposes or stress testing purposes.

- A significant challenge will therefore be the ability of organisations to reliably forecast the factors that will be used in the scenarios and models.

#### Model Risk

- If these challenges are not addressed or considered appropriately, it could lead to additional model risk, misuse of models and significant capital and ECL impacts.
- Having a clear objective, robust governance process and adequate monitoring framework could help address these concerns and minimise the risk.

## QUESTION 2

By the end of 2021, the London Interbank Offer Rate (LIBOR), one of the global benchmark rates for financial products ranging from loans and bonds to derivatives, will be replaced. LIBOR is one of the Interbank Offer Rates (IBOR) used globally to set the benchmark rate for a wide range of financial products.

South Africa will also be affected by the transition, with JIBAR being discontinued and replaced by a local South African alternative reference rate. The figures below illustrate a multi-curve pricing framework pre and post transition.

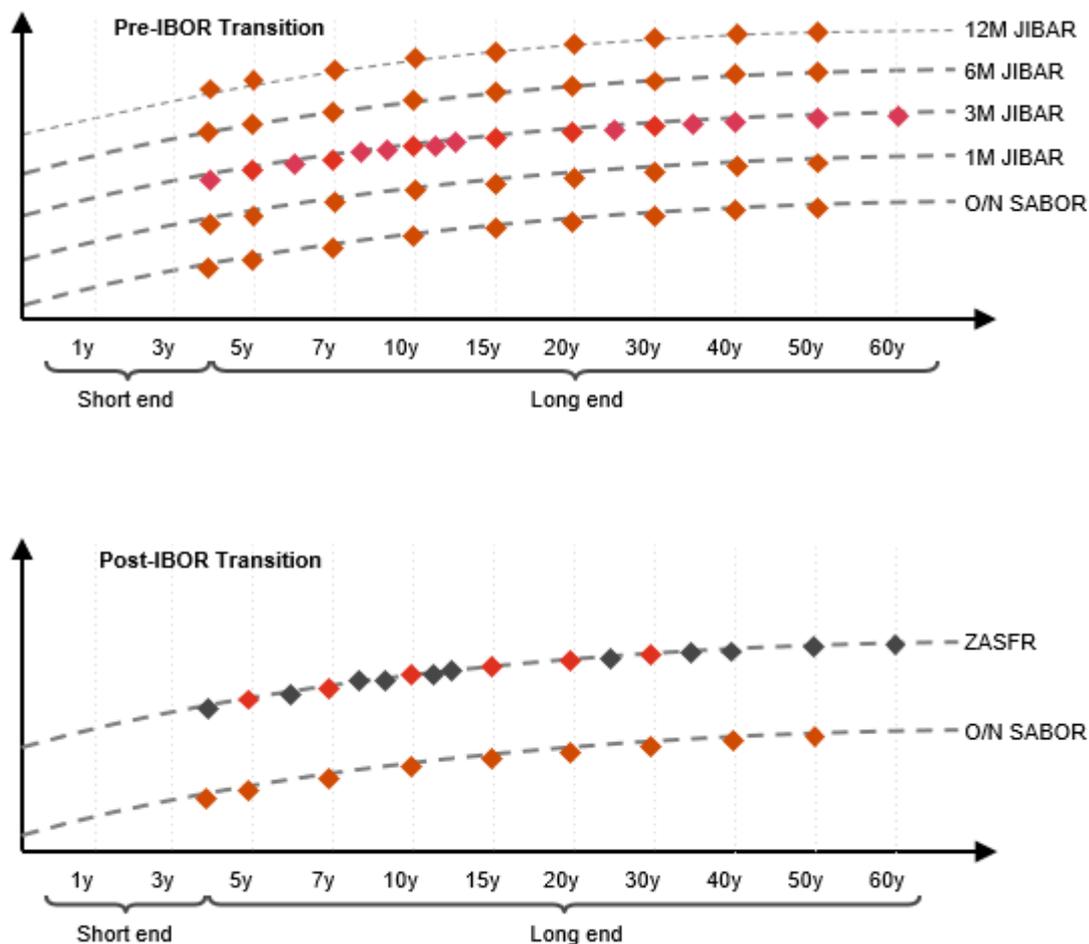


Figure: Representation of multi-curve pricing framework pre and post IBOR transition

Where:

SABOR is the South African Benchmark Overnight Rate.

JIBAR is the Johannesburg Interbank Average Rate is the money market rate, used in South Africa. It is calculated as the average interest rate at which banks buy and sell money.

ZASFR is South African Secured Overnight Financing Rate.

i) Briefly discuss the change above and the implications from a valuation process point of view.

[8]

- When JIBAR ceases, the multi-curve valuation framework will fundamentally change as typically curves are marked as a basis to a JIBAR curve (e.g. JIBAR 3 month curve).
- Under the previous framework:
  - JIBAR has several tenors – overnight, 1 week, 2 M, 6M, 1 Y
  - Since JIBAR is a term rate, the payments are known in advance at the beginning of the payment period.
- Valuations will need to consider the likelihood of JIBAR cessation and resulting trigger of contractual fallbacks (the rate to which contracts will default).
- Under the new framework:
  - Alternative Risk-Free Rates (RFRs) will be used instead of JIBAR- style reference rate (ZASFR etc).
  - In this rate selection process, there are a few rates are selected in the shortlist.
  - RFR is an overnight rate, unlike JIBAR that is a term rate.
  - Therefore, to calculate the term rate a compounded rate must be calculated.
  - The interest rate payable is not known until the end of the payment period “backward-looking”.
  - When JIBAR is discontinued, Fallback rate will be used (for all contract that previously quoted in JIBAR will use this fallback rate instead).

Key Issues with the transition:

- Rounding issue: the backward-looking calculation (for compounded rate calculation).
  - Systems that struggle to store necessary precision for intra-period calculations may round off significant digits.
  - This may result in discrepancies in the final coupon amount and thus, settlement disputes.

- Payment: The backward-looking nature of the fall-back is incompatible with contracts that necessitate knowing a JIBAR fixing shortly before payment.
    - There may be potential mismatches between deposit and derivative dates.
    - There may be outright incompatibility. (e.g. interest rate swap between fixed and floating rate.)
  - Models that mathematically describe JIBAR dynamics will require several updates to account for the change in rate dynamics associated with backward-looking compounded rates.
  - The majority of the RFRs have come into existence only recently so the time series of their values are have limited historical coverage.
  - More importantly, the markets for instruments based on the new rates are either not well developed or currently non-existent.
  - Each of these situations have implications for the calibration and output of risk models.
- ii) As a CRO of a large South African Bank, you are concerned about the impact on different areas of the risk function of the transition away from JIBAR to new reference rates.

Briefly discuss the potential impact of the change on the main risk areas. [7]

The impact of the transition away from JIBAR can be summarised as follows:

#### Market risk

- The use of new RFRs will introduce additional basis risk in cash and derivatives, and in cross currency swaps.
- This could also have significant implications for existing hedging strategies (including costs).
- Uncertainty around volatility 'smile' and respective correlations of the curves could impact the economic value of the trades, which if not managed carefully could result into significant P&L impact.
- Many of the existing front office as well as market risk models reference JIBAR, transition away would mean firms needing to re-write (or tweak) existing risk, pricing and valuation models.
- Lack of liquidity in the new RFRs could potentially require firms to hold more capital under the existing Basel III VaR framework as well as FRTB.

### Liquidity risk

- Funding strategy will require a careful re-evaluation. The firms need to consider fungibility of existing funding sources and which of those will need to be replaced and what their new issuances strategy will be (across currencies and tenors).
- Moving forward, liquidity in existing JIBAR linked products will reduce, which will cause higher bid-ask spreads. This could potentially have material implications for assets that require quick liquidation.
- Expected increase in intraday volatility alongside reduced liquidity could amplify intraday risks as markets shift and adjust to the new rates.

### Asset & liability management

- ALM measurements and hedges will need to be adjusted as transition to new RFRs could potentially render existing hedges ineffective (due to additional basis risk).
- Cost of hedging also need to be considered.
- ALM analytics infrastructure would also require an update to cater to new data feeds and curves.

### Credit and counterparty risk

- Market pricing changes may impact effective exposure calculations.
- Uncertainty introduced by the transition could impact counterparty cash flows, potentially exposing firms to additional credit risk.
- Advanced IRB models (especially LGD and EAD) may require significant recalibrations due to collateral valuations and changes in recovery rate estimation.
- Firms also need to consider implications on collateral valuations, netting arrangements and hedge effectiveness.

### Model risk

- Model monitoring and validation processes would need to be reviewed as the new risk models go live.
- Approval timetable/backlog should be planned.

### QUESTION 3

You are the Credit Head for the Unsecured Loans Division of Easy Money Bank based in South Africa. Easy Money is a full-service Retail Bank. As a result of Covid 19, many customers have severely reduced income or have lost their income in totality over the last year. This has resulted in massive reductions in loan disbursements (top ups and new loans) across the Retail sector. The Head of Sales has proposed a modified Unsecured Loan product (Super-Flexi Loan) which would have the following adjusted product features in order to assist customers in the medium to longer term:

- Maximum loan term extended to 10 years (from 5 years)
- Maximum loan amount increased from R150k to R250k.
- Customers can select the repayment amount they wish to pay each month
  - These amounts can be as little as R0 and as much as the full outstanding balance in any given month
  - Customers are given full flexibility in this regard throughout the lifetime of the loan commitment
  - The only requirement is to ensure the debt is settled at maturity
  - Since repayments can be at any amount that the customer chooses, it thus means that affordability calculations can be relaxed significantly as in the short to medium term affordability is not an issue
- This product variation can be used for new loans, top ups of existing loans held with Easy Money and for debt consolidations

- i) Describe the concerns you would raise with the Head of Sales with respect to this proposed product modification. [20]

General points:

- All the proposed adjustments lead to an increased risk of losses being made on the loans (in most instances).
  - Extending the term and increasing loan sizes alone increase the value at risk on these deals. Especially since these are unsecured loans.
  - Creating flexibility on repayment terms may help some customers (who genuinely intend to repay the debts), but for many customers this will just lead to poor repayment behaviours (that this behaviour may go unnoticed).
  - Since these loans can be used for Top Ups and Debt Cons, current high-risk clients who are in financial difficulty could top up existing debts and extend terms, while stopping repayments on this new debt for a few years.
- The proposed amendments would allow more loans to be disbursed since:
  - Term extensions should reduce the required repayments (for similar debt sizes), thus allowing more affordability short term.
  - In addition, if it is true that a “zero instalment” can be used for current affordability calculations, customers who are even slightly cashflow positive will be able to “afford” this debt. Short term that is.
  - There is a distinct risk that the current loan base is cannibalised and replaced by this new super flexi debt (on these new far riskier terms).

- There is also a distinct risk that the bank will take on other debt providers risky debts (which will increase sales significantly but at the same time would increase risk dramatically).
- The new product offering does not stipulate at what point in time the customer is required to commit to the size and frequency of repayments on the debt.
  - If the customer is required to commit to these upfront it does eliminate some of the risks and allow a better tracking of what was committed to vs what was received from the customer. This will also allow the bank to understand how the customer plans to settle the debt (since there will be a repayment schedule) and will allow the bank to see if the customer plans to pay a large bullet payment at the end (or not).
  - However, if the customer is at liberty to select a repayment amount on a month to month basis this makes the planning of cashflows and the tracking of customer risk and behaviour very challenging.

#### Credit Risk:

- Credit risk or total credit losses are a function of PD (probability of default), LGD (loss given default) and EAD (exposure at default).
- The proposed changes impact each of these elements differently, hence they are addressed separately below.

#### Default Risk:

- Extending the term of the loan increases the period over which there is an outstanding debt and thus likely will increase the probability of a default occurring on the debt at some point in time in the future.
- That said increasing the loan term does decrease the instalment required which may free up affordability somewhat and could decrease the default risk (for some customers).
- Likewise, the flexible repayment amounts could reduce defaults by allowing customers to repay when they can (rather than forcing a set repayment each month). For some customers this flexibility would decrease their default likelihoods and reduce default rates overall.
- However high risk and low affordability customers are more likely to make fewer repayments upfront and will land up in even greater financial trouble down the line (ultimately resulting in higher default rates).
- Increasing the maximum loan amounts will potentially result in a customer taking larger debt with larger relative instalments (compared to the prior limits), increasing their risk of taking on too much debt and thus defaulting on all debts.

#### EAD Risk:

- The maximum loan amounts have been increased thus the value at risk of the deals increases too.
- The loan term has also increased thus resulting in a good chance that the loan would amortise over a longer period, increasing the relative value at risk through the lifetime of the loan.

- In addition, since the repayments are flexible and there is no minimum repayment, there is a distinct risk that the exposure amortises far slower than normal (it may even increase over time depending on the repayment amounts made by the customer). In fact since no minimum repayment is required the exposure at risk in the final loan month could even be far greater than the original loan amount.
- All these elements increase the EAD through time and thus a larger value is at risk of default all the way through the lifetime of the loan.

#### LGD Risk:

- The LGD percentage may not be directly impacted by the proposed changes, however secondary impacts as a result of the changes could impact the LGD in a negative way.
  - Since there is no required repayment amount, the outstanding debt could grow significantly and at default be very large. As a result, the debt to be collected upon at default will be much higher and thus there is a good chance that the percentage recovered will be lower.
  - In addition, since there is no required minimum payment it will take the bank far longer to identify that the customer is in financial strife and as such by the time the collections process starts there will be far less chance of a successful post default collection taking place.
  - A similar impact would be felt due to the term extension and increased loan amounts, but the impact on LGD percentage would be far smaller.
- The normal collections strategies that the bank would implement on such a product would also need to be adjusted for this different product where potentially no repayments are received for several months (however since no minimum is required, the client has technically not defaulted on the contractual terms). This will require significant strategic changes in the collections space and will make this process far more challenging to successfully implement.
- The principle of running debit orders against the customers' accounts (to help ensure payments are received) will also potentially not work in this instance if the instalments are volatile and amounts are selected by the customer as and when they please. This will result in manual debts having to be submitted or EFT's to be made by the customer (and the bank will have limited ability to enforce these payments).

#### Provisioning & Capital Calculation Challenges:

- Under IFRS9 the bank will be required to raise provisions for expected future losses based on the staging rules created and the relevant PD/LGD parameters assigned within each of these stages.
- The bank will have quite a few challenges setting provisions for this variation for the following reasons:
  - The loan and repayment behaviour is likely to be very different to the current loan book, which means that the assumptions from the current book may not be relevant for the new variation (requiring some expert judgement or peer comparison to assign assumptions)
  - There are no set repayments payable, so identifying customers that should move to different stages in the model becomes near impossible (especially if it is purely based on the behaviour of this loan alone)

- Both these result in the likely situation that the bank will provide incorrectly for these debts
- For the purposes of calculating the bank's capital requirements very similar challenges will be experienced as for provisioning:
  - In terms of the assumptions being used, the PD's and LGD's in place for the existing product may not be 100% relevant and accurate for this amended version of the product. The EAD however could be significantly different given the flexibility of the payments (as such an EAD of well above 100% is very possible on this variation)
  - With respect to the arrears reporting, in all likelihood the definition may not align 100% with how it is defined for provisioning, but it will still rely on accurate and fair missed payment indicators which will not operate in the same way as for standard loans with the group (so some allowance will need to be made for this).

#### Liquidity Risk:

- The cashflows for this loan are difficult to predict given the very flexible nature of the repayments and the overall loan agreement. Especially since the repayment can be as little as R0 and can be as high as 100% of the outstanding loan amount at any point in time
- In addition, the bank does not have a similar product (launched for similar types of customers) where typical behavioural and repayment patterns can be tracked and thus used as a proxy for this product. Given the current economic environment and the reason for creating this variation, one should assume that customers taking up this product would repay more slowly than usual and that tenures would stretch out relative to other loans in the market
- This makes the matching of the cashflows from this asset with other liabilities extremely challenging from a tenure point of view and could make the FTP assignment for this product difficult to allow for accurately
- As a result the bank will probably need to take a fairly conservative view (at least initially) with respect to the calculations and assumptions (assume a longer tenure to ensure there is not a short term liquidity gap created), and the additional cost of this funding will have to be passed onto the customer (resulting in higher rates)

#### System Challenges:

- A standard loan product would typically have flat instalments over the lifetime of the debt. If not flat instalments, they would at least change in a consistent manner over time.
- However, with this proposed amendment there are two issues:
  - If the instalments are not committed to upfront, the system does not know what to expect from the customer each month and thus any arrears triggers and billing from the system will not work as per usual (if at all). So, the system will not be able to bill the customer and collect a payment automatically.
  - There are likely to be other automated processes that are triggered based on payment behaviour, and these may now fail or trigger incorrectly as standard rules in place would no longer apply or would need to be modified to cope with this new type of debt.

#### Affordability Assessment at Inception:

- There would be serious doubts as to whether an instalment of as a low as R0 per month could genuinely be used within the affordability assessments at inception. The NCA clearly states that an adequate affordability assessment must be performed on all new debts written onto a book and it is unlikely that the “flexibility of repayments” as an argument would be seen as satisfactory to the regulator from an affordability assessment point of view.
  - The bank may be able to argue for using an instalment amount that is increasing annually with inflation, and ultimately results in the repayment of the debts by the time the loan hits maturity. However, this would need to be tested with either a representative of the NCR or with one of the legal experts in the group to ensure this proposal is feasible.
  - In the instance where customers have been given temporary pay reductions and where this can be proved based on past data the bank may be able to justify calculating affordability based on the normal income of the customer (again this should be tested with the legal and risk function in the group to ensure compliance).
- ii) Detail some risk mitigants that could be put in place to help to reduce some of the risks and challenges highlighted in part a. These can include alternative modifications as well as other risk mitigants. [8]

#### Possible risk mitigants and alternative product proposals:

##### Risk Mitigants:

If the bank decides to go ahead with the proposed new product and structure, there are several risk mitigants that could be put into place to help to reduce some risk that the bank is exposed to whilst still providing the full flexibility and product offering as listed above:

- Upfront credit risk measures:
  - The bank can offer the product only to customers which have a very good credit risk score (just the top tier customers based on the application scorecard)
  - The bank could limit the product to customers already heavily entrenched with the bank (hold many products, cheque account sitting with the bank) as well as customers that have a long standing relationship with the bank (to ensure that long term performance can be shown – historically at least)
  - The offer could be limited to customers that work in specific industries and professions (ones which are more resilient to change and are typically more sustainable long term) or customers with only short-term income reductions
  - Quite severe limits could be placed on the volumes and total book values of loans that can be disbursed for this specific product offering (to keep the overall exposure to this variation reasonable low and manageable)
  - The maximum loan amount available to the customer can be tiered based on several risk metrics (tenure with the bank, risk score, any level of collateral offered), in order to reduce risk while still theoretically offering a larger maximum loan for appropriate customers
  - Some level of collateral could be requested in order to help reduce the LGD experienced and reduce the losses post default
  - Customers should be charged a premium for the level of flexibility (and risk) being offered on this product variation. A higher rate will need to cover the funding

mismatch premium required and cover the additional credit losses from the product (and may deter some customers from taking the offering unnecessarily)

- On book risk measures:
  - The bank could enhance customer behavioural tracking (arrears) at the credit bureau to fast track collections efforts on customers that are showing increased credit risk externally (so falling behind in terms of repayments at other providers will be used as a proxy for likely failure to repay the loan)
  - The bank could adjust their missed payment metrics to include some level of negative rolling if customers do not make any payments over several consecutive months or for example have more than a certain number of skip payments within a 6- or 12-month period. Several of these definitions could be created and used for different purposes (collections, external reporting, capital, provisioning) to cover all the required use cases sitting within the bank
  - Tracking can be created at account level to calculate the speed of amortisation of the debts as well as theoretical future instalments required to amortise the debt over the remaining loan lifetime. These can be compared to both payments being received as well as to a typical amortisation. Any debts that are running significantly out of line with the normal can be tagged as concerning debts
  - The bank could send regular communications to the customer (monthly) to remind them of payments due (and post payments made send a thank you and perhaps a mini statement reflecting remaining instalments to be made in order to amortise the loan timeously).

Alternative product proposals:

- Term extensions:
  - Terms could be extended but only by a smaller period (extend to 6 or 7 years, not 10). Although this extension will only have limited financial benefits to customers from an affordability point of view so it may not be worth the effort if the change is not large enough
- Maximum loan amounts:
  - The increase in maximum loan amount could be smaller – perhaps R200k as an example. This would increase the loan amounts offered relative to the current offers but would limit the amounts to a value that is less risky overall
- Customer repayments:
  - There should be some level of minimum repayment required from the customer through the lifetime of the loan
    - This should ideally cover at least interest and fees on the loan each month, to prevent the outstanding balance from increasing month to month
    - The customer should be forced to amortise the loan over the given maturity and should not be left with unreasonably large monthly payments in the last few months (or with a large bullet payment in the last month)
    - There could be some 0 payment or payment holiday months included in the agreement (including for example a 6-month upfront payment holiday), but thereafter some sort of structure and minimum repayment should be instituted
  - The customer should commit to a repayment schedule upfront (even if this includes some months with zero repayments, this commitment should be made upfront so that

these can be loaded to the payments system of the bank, thus allowing some form of automated payment collection to take place). This will also allow for some level of consistency around arrears reporting and rolling of accounts for all purposes and will also allow for more effective and appropriate liquidity management

## QUESTION 5

- i) Outline the steps, with the purpose of each step, followed to develop a probability of default ratings model for a retail a portfolio with enough data points to follow a statistical approach. [12]
- Determine the purpose of the model which will determine the development population and the default definitions to be used
    - Whether the model will be used for underwriting purposes (to rate new applications) or for in-force book rating will determine the population that will need to be modelled.
    - For example, capital or impairment models should be informed by experience from historically similar populations, while for new business rating, the reference experience should match the target market the ratings model will be applied to.
    - If the model will be used in underwriting it will also be important to understand if the model outputs will be used as inputs into the quoting engine
    - If the model will be used to rate the back book, it is relevant whether the model will be used for impairment calculations or economic/ regulatory capital or for account management purposes
  - Establish the master modelling dataset, this dataset that will be used to inform the ratings study, by linking:
    - all exposures with
    - the record of every exposure's risk characteristics/ features that are candidates for the final ratings models at the appropriate dates with
    - the outcome/ default for each exposure
  - Record exclusion to ensure data set used to inform the model (the modelled population) will reflect the application population and experience
    - For example, exclude historic lines of business that will not be continued in future (e.g. policy exclusions)
    - Exclude records that were exposed to experience not expected to repeat in the prediction period (e.g. lock-down periods)
  - Define model target definition through data analysis
    - Apply a modelling default/ target definition to every record, ensuring the target is sensitive enough to manifestation to credit risk and credit costs, but not overly sensitive to trigger false credit events
  - Data exploration to identify outliers, measure the extent of missing values and possible data issues in the data set
    - Outliers may have excessive impact on model estimates and should be addressed either through truncation of record exclusion

- Features with high levels of missing values or inconsistent patterns on missing values over time may negatively impact model application
- Characteristic/ feature evaluation to narrow set of candidate features/ characteristics for use in model
  - Evaluate potential characteristics and classing of characteristic values using optimising algorithms and evaluation statistics
  - Specifically test for non-intuitive trends that are inexplicable
- Model construction
  - Use chosen statistical or machine learning routine to configure optimal combination of characteristics to produce a single rating per exposure in the population
  - Test for overfit by validating performance statistics with a significant hold-out sample
  - This is likely to be an iterative process of optimisation
  - The aim is to be able to create a range of risk segments with different expected credit experience as reflected by historic experience.
- Conduct final intuitive review to ensure all changes in characteristics/ feature values directionally result in a directional change in rating
- in final review, also check different sub populations of the portfolio to determine model weaknesses or areas where alternative approaches might need to be considered
- add validation test step to test model on validation data sample (separate from training sample) and look at out of time sample as well
- Calibrate rating to applicable probability of default outcome window and definition as appropriate for use in the model with reference to the principles of correspondence and exposure-at-risk
  - Ensure the calibration of the event/ default definition is consistent with regulatory requirements in the case of capital models
- The impact of the new model will need to be tested, for example changes in RWA/ EC or changes in approval rates or risk premiums
- In cases where ratings will be applied by inference to actual experience the calibration exercise and or the model build exercise needs to consider the possibility that the inferred performance may be different from what may really transpire (“reject inference” in the case of new business underwriting model). For example, if a class of application will now be approved which was not approved in the past (and hence no actual experience available to infer performance)

- ii) You are the CRO of Trust Bank. Trust Bank offers vehicle finance to all retail market segments and the management team has embarked on a project to enhance the probability of default rating models used to assess counterparty credit risk at loan application stage for use in underwriting and loan pricing. The development process has resulted in two different ratings model options and the team has provided you with a report comparing the two options.

Discuss the relative merits of the two ratings models using the information provided. [21]

Table 1: General information

<b>Aspect</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
Development sample	New bookings period January 2006 to January 2016	New bookings period January 2015 to January 2016
Outcome period	12 months on book	15 months on book
Target definition	3 missed instalments in the outcome period	2 missed instalments in the outcome period
Out of time experience	Bookings in Jun 2018	Bookings in Jun 2018
Default definition for calibration	Basel 3 outcome at 12 months on book	Basel 3 outcome at 12 months on book
Data exclusions	Policy rule declines	Policy rule declines and all records in arrears due to insurance claim or death
Optimisation/ Model construction method	Logistic regression	Machine learning: Random forest
Number of characteristics/ features	21	30

\*\* Experience data from lock-down/ covid period specifically excluded

Table 2: Population analysis

<b>2.1 Discriminatory power on target definition</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
In sample Gini* coefficient	55%	58%
Out of sample Gini coefficient	54%	50%
Out of time Gini coefficient	43%	48%

<b>2.2 Discriminatory power on default definition</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
In sample Gini* coefficient	55%	56%
Out of sample Gini coefficient	54%	48%
Out of time Gini coefficient	43%	46%

<b>2.3 % pop total applications predicted to have acceptable default rate (approval rate)</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
In-sample	20%	30%
Out of sample	21%	26%
Out of time sample	22%	33%

<b>2.4 % of previously declined applications now approved (swap-ins)</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
In-sample	5%	10%
Out of sample	5%	5%
Out of time sample	7%	15%

\*The Gini coefficient is a metric that estimates a model's discriminatory power, with higher gini's indicating higher discriminating power.

Table 3: Sub-population analysis (based on out of time sample)

<b>3.1 High income sub-population</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
Gini	40%	10%
Approval rate	40%	50%
Declined now approved	3%	20%

<b>3.2 Low income sub-population</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
Gini	40%	60%
Approval rate	10%	11%
Declined now approved	3%	30%

<b>3.3 New customer sub-population</b>	<b>Ratings model A</b>	<b>Ratings model B</b>
Gini	35%	40%
Approval rate	15%	25%
Declined now approved	3%	15%

- General information development sample:
  - Ratings model A is based on more history and would have more records and as such a larger experience dataset on which to base parameter estimates on (positive relative to B)
  - The history in ratings model A would include experience from the global financial crises (a stress period) (potentially a positive relative to B)
  - Experience from reference period pre-2015 (Model A) could be used to inform stress estimates of probability of default (positive relative to B)
  - The experience from business done in 2015 and earlier are arguably less relevant to future periods, depending on how market dynamics has changed (potentially negative for model A relative to B)
  - Possible accurate history of all the candidate characteristic/ features used to enhance predictive power may not be available prior to 2015 (potentially negative for model A relative to B)
  
- General information- Outcome period:
  - Ratings model A has a shorter outcome period than B
  - The most desirable outcome period depends on the time it takes for default risk to emerge in this portfolio and it is not possible to say which approach is better suited without additional information
  - A too short an outcome period may result on too few defaults to adequately explore risk trends
  - A too long an outcome period may result in dilution of risk understanding as client circumstances post rating date may changes over time, making factors at inception date less relevant
  
- General information- Target definition:
  - Ratings model A has a more strict target definition than B;
  - The most desirable target definition depends on how costly from a credit risk perspective the target definition is
  - A target definition that is too easily met (and as such not costly) may result in a model that is too sensitive for insignificant events; whilst if the target definition is too hard to meet, the ratings model may not be sensitive enough to significant events.
  
  - The choice of target definition is linked to the choice of outcome period and more information would be required to determine which model approach would be best for this specific portfolio
  
- General information- Data exclusions:
  - Ratings model B's development sample excluded credit events which were likely triggered by non-credit related causes. This would benefit the sensitivity of the ratings system for differentiating true credit risk
  - For calibration purposes, the impact of these types of events on ultimate losses needs to be explicitly considered if not contained in the pure credit risk premium
  
- General information- Optimisation method
  - Logistic regression methods typically result in models that are easier to implement in host systems due to linearity

- Modern platforms do accommodate the implementation of machine learning models
  - Logistic regression methods typically result in models that are easier to interpret due to linearity
  - Machine learning methods may incorporate relationships in the underlying data that the modeller did not intuitively expect; if understood and the underlying economic causation is understandable and evaluated, this is desirable
  - Out-of-sample and out-of-time evaluation of model performance allows consistent objective evaluation of the two different approaches
- General information- Number of characteristics/ features:
    - Model A uses fewer characteristics to assign a rating. This may result in the ratings model A to be less sensitive to risk than model B (comparative disadvantage)
    - Conversely, a model with more characteristics may have a higher likelihood of “over-fit” which may result in the model not being as effective in ratings a general population
- Population analysis- Discriminatory power on target definition
    - Model A statistics reveal little deterioration in statistics between development and out-of-sample set, with higher deterioration with the out-of-time sample. This indicates that the model may not perform as well on more recent experience
    - Model B statistics reveal deterioration between development sample and out of sample and out of time sets, indicating possible elements of overfitting
- Population analysis- Discriminatory power on default definition
    - Similar patterns to discriminatory power analysis for target definition
    - On a consistent default definition model B performs better on recent experience and seems to have a comparative advantage
- Population analysis- Approval/ acceptance rate
    - On all samples model B identifies a larger population for acceptable risk
    - Model A was built referencing a period of stress, as such the predicted default rates estimated by Model A would be a higher resulting in a lower approval rate
    - This may be due to the higher discriminatory power as evidenced by the gini coefficient
    - The comparatively large difference may be an indication of high discriminating power near the marginal acceptable default rate
    - The comparatively large variances between the samples for model B points to potential stability issues which needs to be evaluated further
- Population analysis- Swap-ins
    - Previous declined deals that will now be booked constitutes a set of business for which no actual experience, or only limited experience is available
    - Model B swaps in comparatively more business than Model A, to a large extent explaining the higher approval rates
    - The swap set constitutes a risk that the inferred performance may not transpire as expected and as such model B present more uncertainty for this set of business than Model A

- Sub-population analysis: High income
  - Ratings model B has a poor ability to discriminate risk in this segment compared to Model A (out of sample)
  - This indicates to a failure in the modelling technique to describe the default experience in this segment
  - Such failure may be ascribed to low volumes in experience OR contradictory trends in default rates per characteristics as opposed to other segments
  - Model A is more suitable, while Model B is not suitable for use in rating high income applications
  
- Sub-population analysis: Low income
  - Ratings model B has good ability to discriminate risk in this segment compared to Model A
  - This indicates to a strength in the modelling technique to describe the default experience in this segment
  - This strength may be ascribed to comparatively high volumes of records in this segment, typically areas in which ML techniques perform well
  - Model B is more suitable for use in rating low income applications
  - The comparatively large swap-in set needs to be evaluated further and monitored should this option be implemented
  
- Sub-population analysis: New customer sub-population
  - Ratings model A exhibits better discriminatory power for this sub-population
  - This also translates results in a higher approval rate and larger swap-in set
  - Given the result for low- and high-income sub-populations and analysis on new customers by income would be required to confirm full suitability

iii) Detail possible risks associated with the implementation of a new ratings model, with associated risk mitigation measures [6]

- Implementation of model monitoring framework post model dev critical. Also need post model implementation reviews to check whether model outcome is as expected
- The model may be implemented incorrectly/ inaccurately due to coding errors affecting the calculation of characteristics/ features or aggregation or translation into PDs
  - This can be mitigated by step-by-step comparison of results on sample records ensuring exact replication of the model into the production system
  - Given the number of permutations possible, it is advisable to create a sample universe that can cover many possible outcomes to automate the comparison (as opposed to case by case manual tests)
- The creation of a test/pre-production/production environment can decrease the risk of incorrect publishing of the model and ensure an environment for checking and testing.
- Recoding risk: The model is coded in one language and implementation is required to be in another language, this could be due to system or licensing constraints. Ensure sufficient skills to recode and test.
- The actual default rates may differ from those anticipated by the model due to various causes
  - On swap-in sets expected default rates are inferred (not based on actual experience) and as such may differ
  - The performance period/ (the period the new loans are exposed to risk) may differ from that implied in the calibration period
  - Early delinquency performance on delinquency needs to be tracked for critical sub-populations to allow early response to adverse experience
  - Experience may also differ if the population of loans rated changed significantly from the model development sample, for example a change in average income
  - Population stability metrics needs to be tracked at application stage to evaluate and possible changes and allow for response
  - Tracking approval rates as a form of population stability tracking will also be important to evaluate application stage to evaluate and possible changes and allow for response