ISOM 677 Project 3
Regency Bank

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Outline

1. Problem Summary
2. Simulation Model Structuring
3. Three-year Simulation Model
4. Risk Level Analysis
5. Different Policies for Migration
6. Conclusion & Business Insights

Regency Bank Case Overview

Company Overview
Regency Bank, in its strategic expansion, has acquired a portfolio of 2000 clients from Continental Bank, a subsidiary of the U.S.-based Continental Group. This portfolio, purchased for $64 million, is expected to generate significant annual revenues.

Central Question
How Regency Bank can optimally integrate and manage this newly acquired client portfolio to maximize profitability while effectively managing risk.

Objective
Develop **a comprehensive simulation model** for Regency Bank to **maximize the profits** gained through the acquired client portfolio.

Structuring Simulation Model

Objective: maximize Profit = Revenue - Cost

Revenue:

- Charge 1% of the total annual spend plus a flat rate of $5,000 per client

Cost:

- Migration costs of $500,000 as a fixed component, plus $2,000 per account
- Ongoing annual operating costs were estimated at $200,000, plus $1,500 per account
- Cards related cost: $45 for issuing new cards and $40 for serving a card

Structuring Simulation Model

Client Complexity Levels

Clients were categorized into three levels of complexity based on their reporting needs, card requests, and service requirements. Each level had different migration and operating costs associated with it:

- **Level 1:** Standard level of service, costing $2,000 to migrate and $1,500 annually to operate.
- **Level 2:** Required expanded reporting tools, costing an additional $3,000 to migrate ($5,000 total) and an additional $500 in annual service costs ($2,000 total).
- **Level 3:** Required special reporting needs and a high level of interaction, costing an additional $5,000 to migrate ($7,000 total) and $1,500 additional in annual service costs ($3,000 total).

Structuring Simulation Model

Risk of Default

Risk ratings were assigned to each client. The risk of a client defaulting on their card account varied with the risk rating, as did the potential cost of default measured in terms of months of charges written off

Attrition

An attrition rate of 10% per annum was estimated for each client account. Additionally, it was predicted that annual spending and the number of cards per account would grow at mean rates of 8% and 10% per annum, respectively, with a standard deviation of 1%.

Q1: Simulation Model for each potential client

Define Revenue and Cost

- **Revenue**: The code sets an annual_fee_percentage (1% of annual spend) and a fixed_fee (5000 dollars). These represent the revenue streams from each client.
- **Costs:** Several costs are defined, including fixed migration costs, migration costs based on client complexity, annual operating costs, and card-related costs. These costs are essential for calculating the net revenue from a client.

```
# revenue

annual_fee_percentage = 0.01  # Fee as a percentage of annual spend
fixed_fee = 5000  # Fixed annual fee in dollars

# cost
fixed_migration_cost = 500000  # Fixed component of migration cost
migration_cost_factors = {1: 2000, 2: 5000, 3: 7000}


annual_operating_cost_fixed = 200000  # Fixed annual operating cost
annual_operational_cost_factors = {1: 1500, 2: 2000, 3: 3000}


card_issue_cost = 45  # Cost to issue a card
card_annual_service_cost = 40  # Annual cost to service a card
```

Q1: Simulation Model for each potential client

Growth Rates and Standard Deviations:

- The code specifies **mean growth rates** and **standard deviations** for both annual spending and the number of cards. This allows the model to simulate natural variability in client behavior over time.

```
# Growth rates and standard deviations

annual_spend_growth_mean = 0.08  # Mean growth rate of annual spend
annual_spend_growth_std = 0.01  # Standard deviation
card_growth_mean = 0.10  # Mean growth rate of number of cards
card_growth_std = 0.01  # Standard deviation
```

Q1: Simulation Model for each potential client

Default Risk Parameters

- **risk_of_default** and **months_to_write_off**: These dictionaries map the client's risk rating to the probability of default and the number of months of charges to write off in case of a default.
- This is crucial for assessing the credit risk associated with each client.

```
# default risk
risk_of_default = {
    1: 0.001,  # 0.1% risk of default
    2: 0.005,  # 0.5% risk of default
    3: 0.01,   # 1% risk of default
    4: 0.02,   # 2% risk of default
    5: 0.03,   # 3% risk of default
    6: 0.05,   # 5% risk of default
    7: 0.10    # 10% risk of default
}

months_to_write_off = {
    1: 3,  # Months of charges to write off for risk rating 1
    2: 3,  # Months of charges to write off for risk rating 2
    3: 3,  # Months of charges to write off for risk rating 3
    4: 3,  # Months of charges to write off for risk rating 4
    5: 3,  # Months of charges to write off for risk rating 5
    6: 4,  # Months of charges to write off for risk rating 6
    7: 6   # Months of charges to write off for risk rating 7
}
```

Q1: Simulation Model for each potential client

calculate_profits Function

This function calculates the total net revenue from a client over three years.

- **Annual Increases:** It generates random growth factors for annual spending and card numbers for each of the three years, introducing variability into the simulation.
- **Yearly Calculation Loop:**
  For each of the three years, the function calculates:
  1. The client's annual spend and number of cards.
  2. Total revenue from fees (annual fee based on spending and fixed fee).
  3. Various costs (operational, card-related, and migration costs).
  4. Potential losses due to default, based on the client's risk rating and a random chance of default.

```
default_prob = risk_of_default[client_risk_rating]
        if np.random.binomial(1, default_prob):
            default_occurred = True

            default_months = months_to_write_off[client_risk_rating]
            default_loss = annual_spend * (default_months / 12)
            yearly_default_loss += default_loss
```

Q1: Simulation Model for each potential client

calculate_profits Function (Continued)

- **Yearly Calculation Loop (Continued) :**
  The **net profit** for each year is aggregated to determine the total net profit over three

```
net_profit = annual_fee - annual_operational_cost - card_related_cost - migration_cost - yearly_default_loss
total_net_profit+= net_profit
```

- **Points of note:**

1. Ensure the loop terminates immediately upon a client's default

```
if default_occurred == True:
    break
```

Note: Since we only need to consider one client for Q1, we didn't include attrition rate for simplicity. Calculation of attrition rate is included in Q2.

Q2: Simulation Model for all potential clients

Further Analysis

Based on the objective function and constraints made in question 1, we need to build a more comprehensive model that includes all the variabilities in Question 2.

Yearly Loop Process:

- Initially, we loop through the years.
- Following the initial phase, we select the indices of attrited clients and remove them from our dataset.

```
def apply_attrition(df, attrition_rate):
attrited_clients = np.random.binomial(n=len(df), p=attrition_rate)
attrited_indices = np.random.choice(df.index, size=attrited_clients, replace=False)
return df.drop(attrited_indices)
```

Q2: Simulation Model for all potential clients

Looping Through Each Customer:

- We then enter another loop, iterating over each row in the dataset, representing each customer.
- In the first year's beginning, we confirmed that there were no increases in the number of cards and annual spending

Points of note:

- It is important to note that once a default occurs, the customer needs to be dropped from consideration.

```
# Calculate potential cost of default and remove defaulted accounts
df_sim['Default'] = np.random.rand(len(df_sim)) < df_sim['Risk Rating'].map(risk_of_default)
df_sim['Cost of Default'] = df_sim['Default'] * df_sim['Annual Spend Volume'] \
                            * df_sim['Risk Rating'].map(months_of_charges_written_off) / 12
total_cost += df_sim['Cost of Default'].sum()
df_sim = df_sim[~df_sim['Default']]  # Remove defaulted accounts
```

Q2: Simulation Model for all potential clients

Results:

	Total Revenue	Total Cost	Net Revenue
Max	2.670835e+07	5.044875e+07	2.017060e+07
Min	2.115645e+07	4.713601e+06	-2.587956e+07
Std	9.425450e+05	6.991207e+06	7.256772e+06
Median	2.457855e+07	1.655172e+07	7.978148e+06
Mean	2.450953e+07	1.769126e+07	6.818273e+06

- The median Net Revenue is approximately $7,978,480, which is higher than the mean of $6,818,730, suggesting a skew in the distribution of Net Revenue
- While there are scenarios where the company makes a substantial profit, there are also scenarios resulting in a loss. The relatively high standard deviations indicate a high level of risk or uncertainty in the outcomes.

Q3 : Choose the Best Risk Level for Migration

Risk Management:
Higher-risk clients are more likely to default, which can lead to significant financial losses.

Incorporate into our simulation model:
We created a list of all risk rating combination and plug in these combinations into simulation to evaluate the performance for combining different risk levels.

```
risk_rating_combinations = [
    [1],
    [1, 2],
    [1, 2, 3],
    [1, 2, 3, 4],
    [1, 2, 3, 4, 5],
    [1, 2, 3, 4, 5, 6],
    [1, 2, 3, 4, 5, 6, 7]]
```

Q3 : Choose the Best Risk Level for Migration

By the comparison between the result on the right part, we can see the net revenue for our best risk level of migration, from 1 to 5, is better than migrating all customers. Regency Bank could gain **additional median profit of 2.52 million dollars.**

After 1000 times simulation, we find out **the combination with best performance is [1, 2, 3, 4, 5]**, which is saying that migrating only the customers from risk rating 1 to risk rating 5 would generate the most profit to Regency Bank. **The median profit for this combination is 11 million dollars.**

Combination: [1, 2, 3, 4, 5]

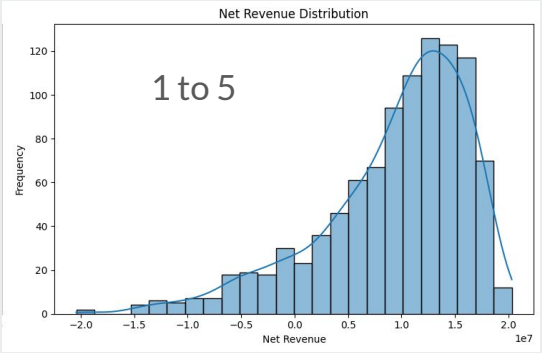
	Total Revenue	Net Revenue
Max	2.480881e+07	2.032072e+07
Min	1.936617e+07	-2.043104e+07
Std	9.349898e+05	6.971047e+06
Median	2.283044e+07	1.108209e+07
Mean	2.275913e+07	9.353748e+06

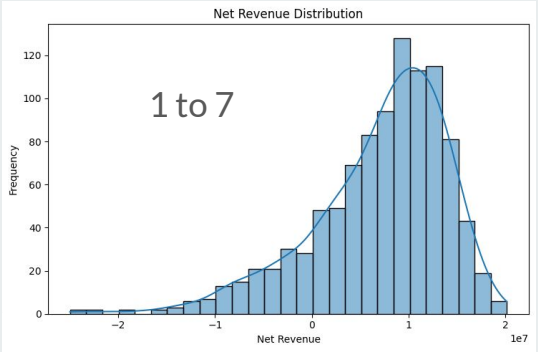
Combination: [1, 2, 3, 4, 5, 6, 7]

	Total Revenue	Net Revenue
Max	2.661427e+07	2.017403e+07
Min	2.028358e+07	-2.498806e+07
Std	9.601293e+05	7.012056e+06
Median	2.462447e+07	8.564577e+06
Mean	2.453174e+07	7.010731e+06

Q3 : Choose the Best Risk Level for Migration

Based on the net revenue distribution of combination of risk rating 1 to 5 and 1 to 7 shown on the right, we would use **median** to evaluate the performance since these distributions are both left skewed. Also, the frequency of 1 to 5 risk level **distribution is more condensed** on the side with larger net revenue, which becomes the reason why it has **larger median** and **lower standard deviation**.





Hence, after evaluating the number of customers with risk rating from 1 to 5, we can conclude that:

- **The best risk level for migration decision is 1 to 5**
- **189 customers which with targeted risk level should be migrated**
- **It is better than migrating all customers to gain an additional 2.52 million dollars profit**

```
Number of customers with Risk Rating from 1 to 5: 189
```

Q4 : Different Migration Strategy - Complexity Level

We firstly generate the analysis if we just use the **complexity level** to filter clients. The reason why we group them into three as [1], [1, 2], [1, 2, 3] is follow the logic that **with higher complexity, Regency Bank would undertake higher migration and operational cost.** That is why we could only consider the cumulative combination.

By put these combination into our original model and simulate for 1000 times, we could get the result at the right side. The combination with **best median net revenue is including all complexity levels, which is 8.26 millions dollars.**

Combination: (1,)

	Net Revenue
Max	2.812736e+06
Min	-1.022561e+07
Std	1.959594e+06
Median	5.647128e+05
Mean	1.430400e+05

Combination: (1, 2)

	Net Revenue
Max	1.164319e+07
Min	-1.927583e+07
Std	4.780691e+06
Median	5.695222e+06
Mean	4.447807e+06

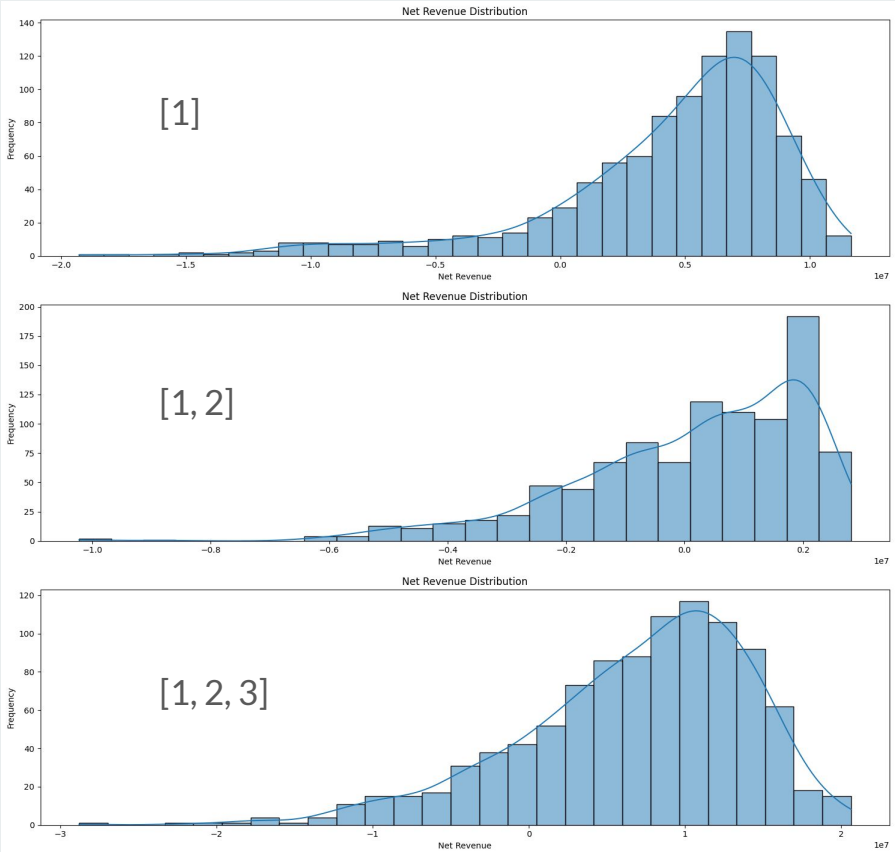
Combination: (1, 2, 3)

	Net Revenue
Max	2.062833e+07
Min	-2.880298e+07
Std	7.297275e+06
Median	8.260083e+06
Mean	6.827507e+06

Q4 : Different Migration Strategy - Complexity Level

From the standard deviation and distribution side, although the combination of complexity level 1 and 2 has a relatively lower than the combination of all levels, the median is much lower than the latter one and the distribution is more skewed which represent the instability. **Selecting all complexity levels is still the best decision in this dimension.**

Also, since selecting all actually does not change our original strategy of just filtering the risk level, we would not incorporate any complexity level filters.



Q4 : Different Migration Strategy - Size

We measure the **size** by segmenting the customers into **annual spending volume percentile**, each percentile refers to their percentage to the highest amount of annual spending among these customers.

Similarly, we did the grouping cumulatively base on the logic that account with larger size would generate higher revenue to Regency Bank. We make addition to every 10 percentile to the group and generate the result as before.

As the result, selecting the percentile from 80 to 100 will lead to the highest median net revenue as **7.91 million** dollars. **That is saying the strategy of migrating customers in the percentile of 80 to 100 has the best performance if we just choose to filter the size.**

We should look into the incorporation of Risk Level and Size this we have distinct optimal strategy of each of these category.

Group: Percentile 70-100	Net Revenue
Max	1.889555e+07
Min	-2.593908e+07
Std	7.269507e+06
Median	7.538726e+06
Mean	6.018050e+06

Group: Percentile 80-100	Net Revenue
Max	1.702231e+07
Min	-2.722841e+07
Std	6.996392e+06
Median	7.914879e+06
Mean	6.324539e+06

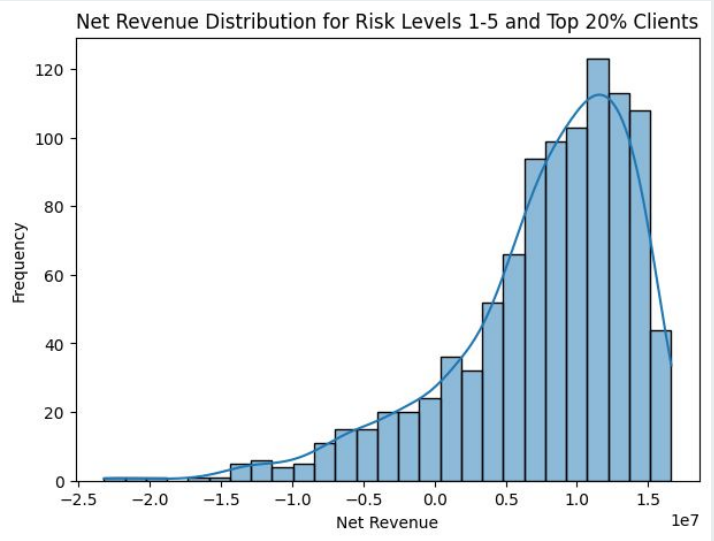
Group: Percentile 90-100	Net Revenue
Max	1.353219e+07
Min	-2.595542e+07
Std	6.697108e+06
Median	7.574611e+06
Mean	5.722082e+06

Q4 : Incorporating Both Risk Level and Size

Risk level and Client Size both gave us clear insights when they are analyzed separately. In this stage, we are considering whether **assessing both risk level and client size** could lead to better outcomes.

We simulated the migration of clients that are both in the optimal risk level range (1-5) and annual spense volume size percentile (Top 20%). The **median net revenue from the simulation was 9.10 million.**

	Net Revenue
Max	1.662584e+07
Min	-2.322517e+07
Std	6.446656e+06
Median	9.103452e+06
Mean	7.688388e+06



Q4 : Incorporating Both Risk Level and Size

However, if we go back to our risk level analysis, we realized that we have a better output when we consider risk level in the migration strategy solely, which means that **we are losing profitability when we apply to many constraints on migration strategy.**

In the future, we suggest Regency Bank to consider how assessing different aspects of clients can affect the profitability and strategically choose a robust strategy to find the balance between financial outcomes and risk management.

	Net Revenue
Max	1.662584e+07
Min	-2.322517e+07
Std	6.446656e+06
Median	9.103452e+06
Mean	7.688388e+06

Net Revenue of Combine Risk Level and Client Size: 9.10 Million

Combination: [1, 2, 3, 4, 5]

	Total Revenue	Net Revenue
Max	2.480881e+07	2.032072e+07
Min	1.936617e+07	-2.043104e+07
Std	9.349898e+05	6.971047e+06
Median	2.283044e+07	1.108209e+07
Mean	2.275913e+07	9.353748e+06

Net Revenue of Only consider Risk Level: 11.08 Million

Conclusion

The simulation model is designed to offer **a comprehensive financial analysis of the acquired corporate card portfolio**.

By considering **various factors such as client complexity, risk ratings, growth expectations, and associated costs**, the model aims to aid Regency Bank in making informed decisions about client migration and portfolio management.

This analysis is crucial for the bank to **strategize its expansion** in the corporate card market and **optimize the return** on its significant investment in acquiring this portfolio.

Conclusion - What We Have Done

- **Objective Evaluation:** A three-year simulation model was developed to assess the profitability of migrating individual clients based on various risk levels.
- **Risk-Based Selection:** The analysis reveals that migrating clients with a risk rating between 1 and 5 maximizes profitability while mitigating risk exposure.
- **Random Variable:** Simulation integrates three key random variables: two binomial variables for attrition and default, and two normally distributed variables for two kinds of annual increase. This stochastic approach captures the inherent variability in client behavior and spending patterns, providing a more nuanced view of potential outcomes.
- **Distribution:** Each policy scenario was simulated 1,000 times to calculate descriptive statistics.The resulting distributions were analyzed, favoring more symmetric distributions as they suggest a more predictable and stable outcome, as opposed to long-tailed distributions which imply higher risk and uncertainty.

Takeaways

- **Risk Stratification**: The selective migration, centered on risk levels 1-5, enables Regency Bank to leverage client profitability while maintaining its conservative risk stance.
- **Complexity and Size**: Iterative simulations across three dimensions (risk, complexity, and annual spend) suggest that complexity and spend size have less impact compared to risk rating in determining migration strategy.
- **Operational Efficiency**: Focusing on risk levels rather than complexity or size simplifies operational processes, leading to more efficient resource allocation.
- **Client Retention and Growth**: By concentrating on lower-risk clients, the bank not only secures a more stable and higher returns revenue stream but also builds a foundation for sustainable growth.

Thank you!