

# Banking System Comparison

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April 2024

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## **Abstract**

In the world of economics and finance, the use of interest has been the norm. Interest based banking has primarily been dominant throughout the world, with interest earned being the main source of income for most commercial banks. However, there is another known paradigm of banking which consists, at its core, of profit and loss sharing (PLS). In recent years, this form of banking is being experimented with and being adopted. The PLS paradigm is mostly adopted and used as the general form of banking in most Islamic countries. If we look back in history, the profit and loss sharing paradigm existed for well over [some period][insert reference here]. Due to the “high profit” nature of interest based banking, the PLS paradigm hasn’t been thoroughly investigated for its lack of use. In this research, we intend to compare these two banking systems both empirically and analytically via mathematical modelling.

During the investigation, to my knowledge, there hasn’t been any proper thesis nor research papers that attempted to model these. The perspective this research is carried out on is in the simple case of acquiring a loan to start a basic trading business, and how long the business may take to pay back the loan in its entirety. Furthermore, this research will investigate the aftermath of the effects of these two systems on the socioeconomic status of a nation as a whole [future studies, yet to be done].

# Chapter 1

## Introduction

In the modern day, individuals in general choose to keep their assets in either liquid form (cash) or non-liquid form (natural resources, minerals, metals, etc). An individual's cash is mostly kept in their respective bank accounts for safety purposes. As a result the individual, being a customer to the bank, pays a security fee and other bank charges to utilize the bank's services. "Any person who receives an item for safekeeping will treat it as a liability. But they may try their best to take advantage of said item while in their possession" – this analogy can be used to describe how a bank treats their customers' money. Any given bank will treat the money of their customers as a liability since the bank does not own it. However, the bank would like to take advantage of it for the time it's there. As such, the bank may choose to invest a certain amount of the money (if not the entire amount) to benefit them. Should profit be gained, it would be as if the customer's money hasn't been tampered with and the bank gets to gain some amount as an advantage. This form of investment can take place in two major forms: giving out loans, or buying shares to invest in a business.

From an economic perspective, there are two major systems of banking, the conventional system and the Islamic system. The most common type of investment for a conventional bank is in the form of loans. Statistics show [put reference of bank's income ratio from interest and loan]% of a bank's income comes directly from the interest they have gained from the loan they issued to their borrowers. This is the primary source of income for a conventional bank. On the other hand, an Islamic bank follows the PLS paradigm. Meaning, from the Shariah jurisdiction of Islam, people are forbidden to deal in, or consume interest [insert reference here]. Hence, an alternative form of "banking" has been used (that being the PLS paradigm).

These two systems are widely used, with Islamic system being preferred in most Arab and Muslim countries. Given that the two systems exist, there hasn't been any analytical comparison or analysis of the two, especially using mathematical tools – to be specific, mathematical modelling. This study aims to find the intricacies, the mathematical nature and nuances of the two systems.

This work aims to deepen the understanding of the two banking systems to better make decisions that may in turn affect the socioeconomic nature of a region.

## Chapter 2

# Islamic Finance

### 2.1 Introduction

Islamic banking, also known as Islamic finance or Sharia-compliant finance, has emerged as a significant force in the global financial landscape. Rooted in the principles of Islamic law (Sharia), it offers a unique financial framework that caters to the needs of individuals and businesses seeking ethical and Sharia-compliant financial products and services. This chapter delves into the core concepts of Islamic banking, exploring its underlying principles, key financial instruments, and its growing importance in the modern economy.

### 2.2 Core Principles of Islamic Banking

The foundation of Islamic banking rests on two central pillars Profit and Loss Sharing, and Underlying Asset Ownership. Sharia prohibits *riba*, often translated as usury, which refers to the charging of interest on loans. Islamic law considers money as a measuring tool for value and not an asset in itself. Therefore, earning interest (*riba*) on money lent is prohibited, as it is deemed unfair. Instead, the concept encourages earning profit through legitimate trade and investment in assets. Instead, Islamic banking emphasizes risk-sharing. Banks and clients enter into partnerships where profits are shared according to a pre-determined ratio, and losses are borne proportionally based on the capital contribution. This fosters a system where both parties have a vested interest in the success of the venture. Products like *Mudarabah* (profit sharing) and *Musharakah* (joint venture) are based on this principle. Islamic finance emphasizes the ownership of underlying assets in transactions. Banks act as financiers or traders, rather than simply lending money. This focus on tangible assets mitigates excessive risk-taking and promotes responsible financial behavior.



## 2.3 Mudarabah (Profit-Sharing Partnership)

Mudarabah is a foundational concept in Islamic finance that embodies a partnership in which one party provides capital while the other provides expertise and management. Often referred to as a profit-sharing agreement, it reflects the Islamic principles of risk sharing and avoidance of *riba* (interest). The sections below discuss the structure, the way this instrument functions, the two main types of Mudarabah, the legal compliance, and its effects on entrepreneurship.

### 2.3.1 Structure of Mudarabah

Mudarabah involves two main parties – The *Rab-ul-Mal* being the investor who provides the capital, and The *Mudarib* being the entrepreneur or manager who invests the capital in a project or business venture and manages the operations. The division of roles is clear; the *rab-ul-mal* is solely a financier, whereas the *mudarib* is the operational manager. This distinction is crucial as it delineates responsibilities and the sharing of profits or losses from the venture.

### 2.3.2 Functioning of Mudarabah

The partnership begins with a contract that specifies the amount of capital invested, the nature of the business venture, and the ratio in which profits will be distributed between the *rab-ul-mal* and the *mudarib*. It is crucial that the agreement explicitly states the profit-sharing ratio, but it must not fix any amount as a lump sum payment or percentage of the capital for either party, as this would resemble *riba*. The *mudarib* utilizes the capital for the business venture, making all the operational decisions. While the *rab-ul-mal* generally does not participate in day-to-day decisions, transparency and regular communication are encouraged to maintain trust. Profits generated from the Mudarabah arrangement are shared strictly according to the ratio agreed upon in the contract. Unlike conventional financing, where returns on investment are typically predetermined, the returns in Mudarabah depend entirely on the success and profitability of the project. In case of a loss, provided it occurred through normal business activity and not due to negligence or violation of the terms by the *mudarib*, the entire financial loss is borne by the *rab-ul-mal*. The *mudarib* loses the time and effort invested in managing the venture.

### 2.3.3 Types of Mudarabah

Mudarabah can be restricted or unrestricted. In the restricted Mudarabah (*Al-Mudarabah Al-Muqayyadah*), the *rab-ul-mal* may specify a particular business or a particular place for the *mudarib*, limiting the scope of where and how the investment can be utilized. In the case of Unrestricted Mudarabah (*Al-Mudarabah Al-Mutlaqah*), the *mudarib* is given full freedom to undertake whatever business he deems suitable, using his best judgment.

### **2.3.4 Legal Shariah Compliance**

Mudarabah must adhere to Islamic laws, which prohibit investments in industries like alcohol, gambling, and pork. The venture must also ensure not to engage in transactions that involve excessive uncertainty (gharar) or speculation (maysir).

### **2.3.5 Implications and Benefits**

Mudarabah's structure inherently encourages risk sharing, which is a fundamental aspect of Islamic finance. Unlike conventional finance where typically the borrower bears all the risk, here, the financier shares in the business risk. By providing capital to those who have skills but lack resources, Mudarabah facilitates entrepreneurial ventures and stimulates economic growth, hence encouraging entrepreneurship amongst the population. Since Mudarabah agreements require compliance with Islamic ethical standards, they inherently filter out business activities that are harmful to society.

## **2.4 Musharakah (Joint Venture)**

Musharakah, which translates to partnership or joint venture, is a pivotal concept in Islamic finance emphasizing risk sharing between all parties involved in a business enterprise. As a form of equity financing, Musharakah allows each party to contribute capital, both sharing in the profits and losses based on their respective investment contributions. The following sections discuss the structure, the way Musharakah functions, the two different types of Musharakah, the legal compliance, and its effects on entrepreneurship.

### **2.4.1 Structure**

Musharakah involves two or more partners who invest capital into a business venture. The key parties in a Musharakah arrangement are the partners and investors. All partners invest some form of capital, which may be financial, tangible assets, or even expertise, although typically, all partners contribute financially. The primary features of a Musharakah agreement are based on Joint Ownership, Profit and Loss Sharing, and Management and Decision making. All partners share ownership of the capital and the assets of the venture. All profits and losses are distributed among the partners according to pre-agreed ratios, which need not necessarily be proportional to the capital invested. Any partner can participate in the management of the business, or they can mutually agree to appoint one or more managers. The level of involvement can vary, but all decisions are generally made jointly or according to the majority in a democratic manner.

### **2.4.2 Functioning of Musharakah**

A Musharakah agreement starts with a contract that clearly delineates each partner's contribution, the profit-sharing ratio, and the responsibilities in management. It must also cover how losses will be managed, typically in proportion to the capital contributions unless agreed otherwise. The business is carried out using the pooled capital under the agreed terms. The flexibility in management allows for dynamic and responsive governance structures, suited to the needs of the business and the skills of the partners. Profits are divided among the partners according to predetermined ratios, which may or may not correspond to the proportion of investment. Importantly, these ratios must be decided at the time the contract is made and not when the profit is being distributed. Upon dissolution of the partnership, any profits made are shared as per the agreed ratios, and the capital is returned to the partners. If the business incurs losses, these too are shared according to the capital contributions of each partner.

### **2.4.3 Types of Musharakah**

Musharakah can be broadly classified into two types – Permanent and Diminishing. In the permanent case, the partnership continues indefinitely, or until the partners decide to dissolve it. It is often used to finance ongoing businesses where capital remains invested. The diminishing type is a special form of Musharakah that allows one partner to gradually buy out the shares of the other partners until the full ownership of the assets is transferred to one partner. This is commonly used in property purchases and project financing.

### **2.4.4 Legal Shariah Compliance**

Musharakah agreements must strictly adhere to Islamic laws, ensuring the venture does not engage in prohibited (haram) businesses such as alcohol, gambling, or pork-related industries. It must also avoid transactions involving excessive uncertainty (gharar) and speculation (maysir).

### **2.4.5 Implications and Benefits**

Musharakah is inherently designed to distribute the business risk between all partners, aligning it closely with Islamic principles which emphasize mutual cooperation, risk sharing, and fairness. It offers flexibility in terms of capital contribution and management, making it adaptable to a wide range of industries and business sizes. The structure promotes mutual trust and cooperation among partners. It encourages collective decision-making and shared responsibility, which can lead to better governance and innovation. By tying the return on investment to the actual performance of the business and sharing losses, Musharakah promotes fairness and discourages exploitative practices common in interest-based systems.

## 2.5 Asset-Backed Financing

Asset-backed financing is a distinctive feature of Islamic finance that aligns with its principles of risk sharing, prohibition of interest (riba), and promoting transactions based on tangible assets or real economic activity. This type of financing ensures that all financial transactions are backed by real, tangible assets or services, which serves to prevent speculation (maysir) and uncertainty (gharar). In this section we discuss Asset-Backed Financing by highlighting its principles, mechanisms, types, and its role in the Islamic financial system.

### 2.5.1 Principles of Asset-Backed Financing

Asset-backed financing is based on physical goods or real assets that have intrinsic economic value. This ensures that financial transactions promote actual economic activity rather than merely generating money from money, which is prohibited in Islam. Because the assets are real and involved directly in the transaction, both the financier and the client share the risks related to asset performance, market fluctuations, and other factors. This aligns with the Islamic principle that rewards should come with risk. As there is a clear prohibition of Speculation and Uncertainty, the transactions must be clear and based on real assets. This promotes fairness and transparency in financial dealings. The assets involved in the dealings must also be ethically permissible under Islamic law. This prohibits financing transactions involving assets related to alcohol, gambling, pork products, and other haram (forbidden) activities, as discussed in above sections.

### 2.5.2 Mechanisms of Asset-Backed Financing

Islamic finance employs several mechanisms to facilitate asset-backed financing, each conforming to the Shariah principles. These include the following:

#### **Murabaha (Cost-Plus Financing)**

One of the most common forms of asset-backed financing, Murabaha involves the Islamic bank purchasing an asset and selling it to the customer at a profit margin agreed upon in advance. The payment can be made in a lump sum or in installments, and the price must be transparent at the time of the contract. The bank bears the risk by owning the asset until it is sold to the customer.

#### **Ijarah (Leasing)**

In Ijarah, the bank buys and leases out an asset. The bank retains ownership of the asset, and the lease payments do not constitute interest but are a return for the asset's use. The bank is responsible for the asset's maintenance unless it leases out the asset 'as is.' This mechanism is akin to renting and is used for both consumer goods and large assets like machinery and vehicles.

### **Istisna (Project Financing)**

Istisna is a contractual agreement for manufacturing goods and commodities, allowing cash payment in advance and future delivery or sale that can be settled at a future date. It's commonly used in project financing, particularly for construction where the financing needs to be linked to milestones.

### **Salam (Advance Payment)**

Salam is a forward sale contract where the payment is made in advance for goods that are to be delivered at a future date. Traditionally used in agricultural financing, it now extends to other sectors. Salam requires the goods to be specified precisely in terms of quality, quantity, and delivery date.

### **2.5.3 Role in the Islamic Financial System**

Asset-backed financing plays a crucial role in promoting economic activities that are in compliance with Islamic principles. It ensures that finance is tied to the real economy. By linking financing to tangible assets and services, it ensures that finance contributes directly to the production of goods and services. Asset-backed financing mitigates the risk of bubbles that occur due to high levels of speculation and debt unsupported by real economic activity, leading to a more stable financial system. Since the financing must be used for halal (permissible) assets, it promotes socially responsible investing and discourages businesses involved in unethical activities.

## **2.6 Gharar (Speculative Behaviour) and Ethical Investment**

Gharar and Ethical investments are fundamental components of Islamic finance, deeply rooted in the principles that guide financial transactions to conform to Shariah law. Both concepts aim to ensure fairness, transparency, and ethical behavior in financial dealings. In this section, we will discuss these concepts in detail, highlighting their significance, implications, and their interplay in the landscape of Islamic finance.

### **2.6.1 Gharar – Concept and Implications**

Gharar refers to excessive uncertainty and ambiguity in the terms of a contract or the subject matter of a trade. In Islamic jurisprudence, significant gharar is considered haram (prohibited) as it introduces a level of risk and speculation that is akin to gambling. For example, contracts for the sale of goods that are not yet in possession of the seller (like fish not yet caught), or sales dependent on an uncertain event (like rainfall) embody gharar. Also, complex derivatives in conventional finance, which are highly speculative, are considered to involve gharar. Contracts must be clear and certain. All essential terms such

as price, delivery, and specifications of goods must be known and agreed upon by all parties. Transactions involving speculation or the selling of items not in one's possession are generally forbidden. Gharar prevents exploitation and ensures that neither party is unfairly disadvantaged by uncertainties in trade agreements.

### **2.6.2 Ethical Investments – Principles and Practices**

Ethical investments in Islamic finance involve putting money into sectors and companies that are not only profitable but also contribute positively to society. This approach excludes businesses that deal in prohibited (haram). The key principles that comprise an “ethical” include that, there are no investment in prohibited activities, social welfare is promoted and the environment is not majorly affected by such practices. Investments must be in industries that do not contradict Islamic values and should benefit the community and promote social justice. Projects that provide employment, improve living standards, or contribute to economic growth are favored. Investments should also consider environmental impact, promoting sustainable practices and environmental responsibility. Ethical investments are applied through instruments like Sukuk (Islamic bonds), equity funds, and direct investments in compliant industries. Screening processes ensure that investments adhere to Shariah principles, with advisors regularly reviewing financial activities to avoid indirect involvement in prohibited sectors.

### **2.6.3 Interaction between Gharar and Ethical Investments**

The avoidance of gharar complements the ethical investment strategy by ensuring that financial practices are not only Shariah-compliant but also inherently designed to foster fairness and transparency. By eliminating uncertainty and speculation, Islamic finance ensures that investments are made in actual economic activities rather than speculative ventures. This promotes genuine and sustainable business operations. Ethical investments are structured to appreciate and mitigate real economic risks rather than speculative risks. This aligns with the reduction of gharar and fosters a stable economic environment. The strict scrutiny required to avoid gharar leads to enhanced due diligence on potential investments. This helps in ensuring that they meet all ethical criteria as well, thus promoting an overall healthier financial system.

## **2.7 Zakat (Almsgiving)**

Zakat, one of the Five Pillars of Islam, is a form of almsgiving treated in Islamic law as a religious obligation or tax, which, by Quranic ranking, is next after prayer in importance. As an integral part of the Islamic faith, zakat is a required charitable contribution and serves as the welfare contribution to the needy and poor. It is a specific, systematic giving which every adult Muslim, if financially

able, is obliged to pay. This section discusses the in-depth aspects of zakat, particularly its role, rules, calculations, and its implications in Islamic finance and investment.

### **2.7.1 Role and Importance of Zakat**

Zakat is not merely a duty on those with wealth, but a right that the poor have over the wealthy. It is meant to be a percentage of wealth that is redistributed to the needy, thus discouraging hoarding, promoting circulation of wealth, and increasing the welfare of the community. The primary objectives of zakat are to “purify one’s wealth” and “themselves”, and to help the needy. By giving away a portion of one’s wealth, a Muslim purifies the rest of their wealth. It purifies the giver from greed, selfishness, and the harmful effects of wealth. Giving zakat provides a means to support those in poverty, helping stabilize the society and promote social cohesion.

### **2.7.2 Calculation and Distribution**

Zakat is payable on the accumulated wealth over a lunar year, including cash, savings, investments, rental income, business merchandise, and precious metals such as gold and silver. The minimum amount of wealth a person must have before they are liable to pay zakat is called the nisab. The haul is the lunar year that is necessary for this wealth to be held before zakat is payable. Nisab is typically measured as the equivalent value of either 87.48 grams of gold or 612.36 grams of silver. The common zakat rate is 2.5% on wealth held over the year that exceeds the nisab threshold. Zakat should be distributed among the eight categories mentioned in the Quran (Surah Tawba, 9:60), which include the poor, the needy, those employed to collect zakat, to reconcile hearts, to free captives, those in debt, for the cause of Allah, and the wayfarer (traveler who is cut off from everything).

### **2.7.3 Zakat in Islamic Finance**

Islamic financial institutions are also subject to zakat. The calculation involves assessing the current assets and subtracting from them the immediate liabilities to establish the zakatable amount. Profits from shares and dividends are also zakatable items. For individual investors, zakat should be calculated on the market value of the assets if the intention is to trade or earn dividends. This includes stocks, bonds (in compliant contexts), and mutual funds among other securities.

### **2.7.4 Modern Challenges and Applications**

The management and distribution of zakat can be enhanced using modern technologies such as blockchain for transparency and ensuring that the funds reach the intended recipients. In many countries, Islamic financial institutions are

required to pay zakat, but there's variability in compliance and methodology. Uniform standards and regulatory oversight can improve the effectiveness of zakat as a tool for social justice. In some Muslim-majority countries, zakat is integrated into the national tax system or collected by dedicated zakat institutions. This formal approach can potentially increase the scope and efficiency of zakat distribution.

## **2.8 Governance of Islamic Banks**

The governance of Islamic banks involves unique challenges and complexities due to the need to comply with both conventional banking regulatory frameworks and Islamic Shariah principles. Islamic banks are not only required to ensure profitability and financial stability like their conventional counterparts but also need to ensure that all their operations and products are in strict compliance with Islamic law. This dual necessity creates a distinctive governance environment, characterized by several key aspects and challenges.

### **2.8.1 Shariah Compliance**

At the core of Islamic banking governance is the adherence to Shariah principles. This involves avoiding interest (riba), uncertainty (gharar), and investments in prohibited (haram) activities. To ensure compliance, Islamic banks establish dedicated Shariah boards consisting of scholars knowledgeable in Islamic finance and law. These boards review and approve all products and transactions.

### **2.8.2 Shariah Board Role and Authority**

The Shariah board's role is crucial and involves issuing fatwas (religious rulings), conducting audits, and providing guidance on financial products. Their decisions are binding on the bank, setting them apart from the advisory role seen in some conventional financial institutions' ethical committees.

### **2.8.3 Risk Management**

Islamic banks face unique risk profiles, including rate of return risk, commodity price risk in Murabaha transactions, and operational risks stemming from the need to manage assets directly (as in Ijarah and Istisna contracts). Effective governance must include frameworks for managing these risks in compliance with Shariah.

### **2.8.4 Transparency and Disclosure**

Given the ethical dimensions of Islamic banking, these institutions are expected to uphold high standards of transparency. This includes clear reporting on how money is used, the nature of investments, and how profits are shared. This



transparency is crucial not only for consumer confidence but also for ensuring Shariah compliance.

### **2.8.5 Regulatory Compliance**

Islamic banks operate in diverse regulatory environments often governed by a central bank or financial authority that may or may not have a deep understanding of Islamic finance principles. This requires Islamic banks to not only follow international banking standards (like Basel III) but also to adapt these standards to Shariah principles.

### **2.8.6 Challenges in Governance**

One of the significant challenges facing Islamic banking is the lack of standardization in Shariah interpretations. Different Islamic banks may have different Shariah boards which might interpret Shariah laws differently, leading to inconsistencies in products and practices both within countries and globally. The integration of Islamic banks into the global financial system poses challenges due to the fundamental differences in principles. The global system is largely interest-based, which complicates transactions such as interbank borrowing, derivatives for risk management, and international regulatory compliance. There is a notable scarcity of professionals who are well-versed in both Islamic finance and modern financial market operations. This gap affects governance because it can be difficult to find qualified personnel to staff Shariah boards and manage Islamic financial institutions in line with both Shariah principles and effective financial management practices. Building and maintaining consumer trust is crucial. Misunderstandings or mistrust regarding the adherence to Islamic principles can affect the reputation and operability of Islamic banks. Effective governance must ensure that the bank not only adheres to these principles but also effectively communicates its adherence to its customers. Keeping pace with technological change, such as the use of blockchain, AI in banking, and online banking platforms, poses a new set of challenges. Islamic banks need to ensure that these technologies comply with Shariah principles while also maintaining competitive services.

## Chapter 3

# Interest Based Finance

### 3.1 Introduction

Interest-Based Banking, the traditional form of banking, is characterized by the use of interest as the primary mechanism for lending and borrowing. This system operates on the principle that banks charge interest on loans and pay interest on deposits. The difference between the interest earned on loans and the interest paid on deposits, known as the interest margin, constitutes the main source of profit for banks. Key features of Interest-Based Banking include interest rates, loan products and risk management. Banks charge borrowers an interest rate on loans and pay depositors an interest rate on their deposits. The rates vary based on factors such as credit risk, loan term, and economic conditions. A wide range of loan products is available, including personal loans, mortgages, auto loans, business loans, and credit cards, each with specific terms and interest rates. Banks assess the creditworthiness of borrowers to manage the risk of default. Higher-risk borrowers are charged higher interest rates to compensate for the increased risk.

### 3.2 Principles of Interest-Based Banking

Interest-based banking is a system that revolves around the principles of charging and earning interest on loans and deposits. The key principles guiding this system include interest rates, profit generation, risk management, and financial intermediation, each playing a crucial role in the functioning and stability of banks and the broader financial system.

#### 3.2.1 Interest Rates

Interest rates are the cornerstone of interest-based banking, representing the cost of borrowing money or the return on deposited funds. Banks determine interest rates based on various factors, including central bank policy rates, market

demand for loans, inflation expectations, and the overall economic environment. Central banks, such as the Federal Reserve in the United States, set benchmark interest rates that influence the rates banks charge each other for overnight loans, which indirectly affect the interest rates banks offer to consumers and businesses.

### **3.2.2 Profit Generation**

Profit generation in interest-based banking primarily comes from the interest rate spread, the difference between the interest earned on loans and the interest paid on deposits. This spread is crucial for a bank's profitability and sustainability. A wider margin indicates higher profitability for the bank, while a narrower margin can signal competitive pressures or higher costs. Besides interest income, banks generate revenue through fees and charges for various services, such as account maintenance, overdrafts, and transaction fees, providing a steady revenue stream that complements interest income.

### **3.2.3 Risk Management**

Effective risk management is fundamental to the stability and profitability of banks. Banks must carefully assess and manage the risks associated with lending and other financial activities. Credit risk assessment involves evaluating the creditworthiness of borrowers through credit scores, financial statements, and other indicators of financial health. This assessment helps determine the likelihood of loan repayment and influences the interest rate charged, with higher-risk borrowers typically charged higher rates to compensate for the increased risk. To spread risk across different sectors, industries, and geographic regions, banks diversify their loan portfolios, reducing the impact of defaults in any single area and enhancing overall stability.

### **3.2.4 Financial Intermediation**

Banks play a critical role as financial intermediaries, facilitating the flow of funds between savers and borrowers, which supports economic growth and development. They attract deposits from individuals, businesses, and institutions by offering a safe place to store money and earn interest. By pooling these deposits, banks can provide substantial funding for loans and investments, contributing to economic activity. They allocate credit to borrowers based on their creditworthiness and the viability of their projects, directing funds to productive uses such as business expansion, infrastructure development, and consumer spending. Efficient credit allocation supports economic growth by funding projects that generate employment, income, and innovation.

The following sections discuss in detail the key principles of Interest Based Banking.

## 3.3 Interest Rates

Interest rates are the cornerstone of interest-based banking, representing the cost of borrowing money or the return on deposited funds. They play a critical role in determining the dynamics of lending and saving, influencing both the financial health of banks and the broader economy. The intricacies of how banks set and manage interest rates, and their impact on borrowers and savers, are fundamental to understanding interest-based banking.

### 3.3.1 Setting Interest Rates

Banks determine interest rates based on a combination of factors, including central bank policy rates, market demand for loans, inflation expectations, and the overall economic environment. Central banks, such as the Federal Reserve in the United States, play a pivotal role by setting benchmark interest rates that influence the rates banks charge each other for overnight loans. These benchmark rates indirectly affect the interest rates banks offer to consumers and businesses.

When setting interest rates, banks must consider the central bank's monetary policy stance, which aims to control inflation and stabilize the economy. If the central bank raises its benchmark rate to curb inflation, banks typically increase their interest rates on loans and deposits. Conversely, if the central bank lowers its benchmark rate to stimulate economic growth, banks are likely to reduce their rates. Additionally, banks must account for the demand and supply dynamics in the market. High demand for loans may allow banks to charge higher interest rates, while low demand may force them to lower rates to attract borrowers. Similarly, competition among banks and other financial institutions can influence the rates offered on deposits and loans.

### 3.3.2 Types of Interest Rates

There are two main types of interest rates: fixed and variable. Each type has distinct characteristics and implications for both borrowers and savers.

*Fixed Interest Rates* remain constant over the term of the loan or deposit, providing predictability in payments and returns. Borrowers benefit from fixed rates as they know their exact monthly payment amounts throughout the loan term, which helps in budgeting and financial planning. Fixed rates are particularly attractive during periods of low interest rates, as they lock in a favorable rate for the duration of the loan. For savers, fixed rates offer a stable and predictable return on their deposits, making it easier to plan for future financial needs.

*Variable (Adjustable) Interest Rates*, on the other hand, fluctuate based on changes in benchmark rates or other financial indices. These rates can initially be lower than fixed rates, making them attractive to borrowers. However, they carry the risk of increasing over time, which can lead to higher loan payments if benchmark rates rise. For savers, variable rates mean that the return

on their deposits can change, potentially increasing with rising market rates but also decreasing when rates fall. Variable rates are often tied to indices such as the London Interbank Offered Rate (LIBOR) or the prime rate, which serve as benchmarks for various types of loans and deposits.

### **3.3.3 Impact on Borrowers and Savers**

Interest rates have a profound impact on both borrowers and savers, influencing their financial decisions and overall economic behavior. For borrowers, interest rates determine the cost of loans. Higher rates increase borrowing costs, making it more expensive to finance purchases such as homes, cars, or business investments. This can lead to reduced borrowing and spending, which can slow economic growth. Conversely, lower interest rates make borrowing cheaper, encouraging individuals and businesses to take out loans for consumption and investment, thereby stimulating economic activity. The type of interest rate (fixed or variable) chosen by borrowers affects their financial planning and risk exposure. Fixed rates provide certainty, while variable rates offer potential savings but with greater risk.

For savers, interest rates determine the return on deposits. Higher rates incentivize savings, as individuals and businesses earn more on their deposits, which can lead to increased accumulation of funds in savings accounts, certificates of deposit (CDs), and other interest-bearing accounts. This can enhance the overall level of savings in the economy, providing banks with more funds to lend. Lower interest rates, however, reduce the return on savings, potentially discouraging saving and encouraging spending and investment instead. The choice between fixed and variable rates affects savers' decisions based on their preferences for stability versus potential for higher returns.

## **3.4 Profit Generation**

Profit generation in interest-based banking primarily comes from the interest rate spread, the difference between the interest earned on loans and the interest paid on deposits. This spread is crucial for a bank's profitability and sustainability, forming the core of its business model. Understanding how banks generate profit involves examining the mechanisms of interest margins, fee-based income, and other complementary revenue streams.

### **3.4.1 Interest Rate Spread**

The interest rate spread, also known as the net interest margin, is the fundamental source of profit for banks. It represents the difference between the interest income generated from loans and other interest-earning assets and the interest expense paid on deposits and other interest-bearing liabilities. Banks earn interest income by lending money to individuals, businesses, and governments at rates higher than what they pay on deposits. For instance, if a bank charges an

average interest rate of 5% on its loans and pays an average interest rate of 2% on its deposits, the interest rate spread would be 3%. This spread provides the primary source of revenue, and the wider the spread, the more profitable the bank. However, maintaining a competitive interest rate spread requires careful management of both lending and deposit rates, ensuring they reflect market conditions and the bank's risk tolerance.

### **3.4.2 Fee-Based Income**

In addition to interest income, banks generate significant revenue through fees and charges for various financial services. This fee-based income provides a steady revenue stream that complements the interest rate spread, contributing to the bank's overall profitability. Banks charge fees for a wide range of services, including account maintenance, overdrafts, transaction processing, and advisory services. For example, customers may pay monthly maintenance fees for checking accounts, penalties for overdrawing accounts, or transaction fees for wire transfers. Additionally, banks earn fees from providing specialized services such as wealth management, investment banking, and financial advisory services. These fees are less sensitive to interest rate fluctuations, offering a stable income source that helps mitigate the impact of interest rate volatility on the bank's profitability.

### **3.4.3 Diversification of Revenue Streams**

Diversification of revenue streams is another critical aspect of profit generation in interest-based banking. By diversifying their income sources, banks can enhance financial stability and reduce dependence on interest income, which can be volatile and influenced by economic cycles and interest rate changes. Banks diversify their revenue streams through various strategies, including offering a broad range of financial products and services. This diversification includes providing credit cards, mortgages, personal and auto loans, business loans, and investment products. Each product and service contributes to the bank's income, spreading risk and reducing reliance on any single revenue source.

### **3.4.4 Asset Management and Investment**

Banks also generate profits through asset management and investment activities. These activities involve managing portfolios of financial assets, including government and corporate bonds, equities, and other securities, to earn returns that contribute to the bank's profitability. Through their asset management divisions, banks invest in a variety of financial instruments, seeking to achieve a balanced portfolio that maximizes returns while managing risk. Investment activities can include trading securities, underwriting new issues, and participating in the capital markets. Profits from these activities depend on market conditions and the bank's ability to manage its investment portfolio effectively.

### **3.4.5 Cost Management**

Efficient cost management is essential for maximizing profits in interest-based banking. By controlling operational costs, banks can improve their profitability even when interest rate spreads are narrow. Cost management involves streamlining operations, adopting new technologies, and optimizing processes to reduce expenses. For example, banks may implement automated systems to handle routine transactions, reducing the need for manual processing and lowering labor costs. Additionally, investing in digital banking platforms can enhance customer service and expand the bank's reach while minimizing the costs associated with maintaining physical branches.

## **3.5 Risk Management**

Effective risk management is fundamental to the stability and profitability of banks within an interest-based banking system. It involves assessing, mitigating, and managing various types of risks associated with lending and other financial activities. Key components of risk management in banking include credit risk assessment, diversification, collateral and security, and regulatory compliance. Each element is crucial in ensuring the bank's financial health and its ability to withstand economic fluctuations.

### **3.5.1 Credit Risk Assessment**

Credit risk assessment is a critical aspect of risk management in banking. It involves evaluating the creditworthiness of borrowers to determine their likelihood of repaying loans. Banks use various tools and indicators to assess credit risk, including credit scores, financial statements, and historical repayment behavior. Banks rely on credit scores, which are numerical representations of a borrower's creditworthiness, based on their credit history, outstanding debts, and repayment behavior. Higher credit scores indicate lower risk, while lower scores suggest higher risk. Financial statements provide detailed insights into a borrower's financial health, including income, expenses, assets, and liabilities. Banks analyze these statements to assess the borrower's capacity to service the loan. Additionally, banks consider the borrower's industry, economic conditions, and the purpose of the loan to gauge the risk involved. The outcomes of these assessments influence the interest rate charged on the loan, with higher-risk borrowers typically facing higher rates to compensate for the increased risk.

### **3.5.2 Diversification**

Diversification is a strategy used by banks to spread risk across various sectors, industries, and geographic regions. By diversifying their loan portfolios, banks can mitigate the impact of defaults in any single area, enhancing overall stability. Diversification involves offering a wide range of loan products, such as mortgages, personal loans, business loans, and credit cards, to a diverse set of

borrowers. This approach reduces the likelihood that a downturn in one sector or region will significantly impact the bank's overall financial health. For example, if a bank heavily lends to the real estate sector and that sector experiences a downturn, the bank may face substantial losses. However, if the bank's loan portfolio is diversified across multiple sectors, such as technology, manufacturing, and retail, the impact of the downturn in real estate will be less pronounced. Geographic diversification also helps mitigate risks associated with regional economic downturns, natural disasters, or political instability.

### **3.5.3 Collateral and Security**

Collateral and security are essential components of risk management in lending. Banks often require borrowers to pledge assets as collateral for loans, which can be seized and sold in case of default to recover the loan amount. Secured loans, which require collateral, present lower risk to banks compared to unsecured loans, which do not require collateral. Common types of collateral include real estate, vehicles, equipment, and financial assets such as stocks and bonds. The value of the collateral is assessed to ensure it adequately covers the loan amount. In case of default, the bank can liquidate the collateral to recoup its losses. This reduces the bank's risk exposure and allows it to offer lower interest rates on secured loans. Unsecured loans, such as credit cards and personal loans, carry higher interest rates to compensate for the increased risk, as they are based solely on the borrower's creditworthiness without any pledged assets.

### **3.5.4 Regulatory Compliance**

Regulatory compliance is vital for maintaining the stability and integrity of the banking system. Banks must adhere to various regulations designed to ensure their soundness and protect depositors. These regulations often mandate minimum capital reserves, loan loss provisions, and regular financial reporting. Capital adequacy requirements ensure that banks maintain sufficient capital to absorb potential losses and remain solvent during economic downturns. For example, the Basel III framework, implemented globally, sets standards for capital adequacy, stress testing, and market liquidity risk. Loan loss provisions require banks to set aside funds to cover potential losses from defaulted loans, improving their ability to manage credit risk. Regular financial reporting ensures transparency and allows regulators to monitor the bank's financial health and compliance with regulatory standards. Compliance with these regulations helps maintain trust in the banking system, prevents financial crises, and protects the interests of depositors and other stakeholders.

## **3.6 Financial Intermediation**

Financial intermediation is a core function of banks, involving the facilitation of funds between savers and borrowers. Banks act as intermediaries by attract-



ing deposits from individuals, businesses, and institutions, and then channeling these funds into loans and investments. This process supports economic growth and development by ensuring that funds are efficiently allocated to productive uses. The primary aspects of financial intermediation include deposit mobilization, credit allocation, and the facilitation of payments and transactions.

### **3.6.1 Deposit Mobilization**

Deposit mobilization is the process by which banks attract and manage deposits from savers. Banks offer a variety of deposit accounts, including savings accounts, checking accounts, and fixed-term deposits, each tailored to meet different needs and preferences of customers. Savings accounts provide a secure place for individuals and businesses to store their money while earning interest. These accounts are typically low-risk and offer liquidity, allowing depositors to access their funds as needed. Checking accounts are designed for frequent transactions, offering easy access to funds through checks, debit cards, and electronic transfers, although they usually offer lower interest rates compared to savings accounts. Fixed-term deposits, such as certificates of deposit (CDs), require depositors to commit their funds for a specified period in exchange for higher interest rates. These accounts provide banks with a stable source of funds, as the money cannot be withdrawn until the maturity date without incurring penalties. By mobilizing deposits, banks gather substantial amounts of capital that can be used to provide loans and other financial services. Effective deposit mobilization relies on offering competitive interest rates, ensuring the safety of deposits through insurance schemes (like the FDIC in the United States), and providing excellent customer service.

### **3.6.2 Credit Allocation**

Credit allocation is the process by which banks lend the mobilized funds to borrowers, including individuals, businesses, and governments. The allocation of credit is crucial for economic growth, as it enables the funding of projects and activities that generate employment, income, and innovation. Banks allocate credit based on an assessment of the creditworthiness of borrowers and the viability of their projects. This involves a thorough evaluation of the borrower's financial health, repayment capacity, and the purpose of the loan. For individual borrowers, factors such as income, credit history, and existing debts are considered. For businesses, banks assess financial statements, business plans, cash flow projections, and industry conditions. Governments may receive loans based on their fiscal health, stability, and economic policies.

The types of loans offered by banks vary widely and include personal loans, mortgages, auto loans, business loans, and credit lines. Personal loans are typically unsecured and used for various personal expenses, carrying higher interest rates due to the lack of collateral. Mortgages are secured loans used to purchase real estate, with the property serving as collateral. Auto loans are similar but are secured by the vehicle being financed. Business loans provide funding for op-

erations, expansion, and capital expenditures, often requiring detailed business plans and financial projections. Credit lines offer flexible borrowing options, allowing borrowers to draw funds up to a pre-approved limit as needed. Efficient credit allocation ensures that funds are directed to productive uses, supporting economic growth by enabling consumption, investment, and innovation. Banks must balance the need to extend credit with the imperative to manage risk, ensuring that loans are likely to be repaid.

### 3.6.3 Facilitation of Payments and Transactions

Banks play a vital role in facilitating payments and transactions, ensuring the smooth functioning of commerce and trade. They provide various services that enable individuals and businesses to transfer funds, make payments, and manage financial transactions.

*Electronic funds transfers (EFT)* are a key service offered by banks, allowing customers to transfer money electronically between accounts within the same bank or between different banks. This includes automated clearing house (ACH) transfers, wire transfers, and online bill payments. Debit and credit cards issued by banks enable customers to make purchases and access cash from ATMs. These cards provide convenience and security, reducing the need for carrying cash.

*Check processing* is another important service, where banks clear and settle check payments between individuals and businesses. Despite the rise of electronic payments, checks remain a widely used method of payment, particularly for large transactions and business dealings.

*Digital banking platforms* have become increasingly significant, offering customers the ability to manage their accounts, transfer funds, pay bills, and conduct other transactions online or via mobile apps. These platforms enhance customer convenience and operational efficiency for banks.

*Robust payment and settlement systems* are essential for the stability and efficiency of the financial system. They ensure that transactions are processed quickly and accurately, reducing the risk of fraud and errors, and enhancing trust in the banking system.

## 3.7 Types of Interest - Simple and Compound Interest

Interest is a fundamental concept in banking and finance, representing the cost of borrowing money or the return on invested funds. There are two primary types of interest: simple interest and compound interest. Each type has distinct characteristics and implications for borrowers and savers. Understanding these differences is crucial for making informed financial decisions and comprehending the mechanics of interest-based banking.

### 3.7.1 Simple Interest

Simple interest is the most straightforward form of interest calculation. It is computed only on the principal amount, or the initial sum of money, for a specified period and at a specified rate. Simple interest is typically used in short-term loans or investments, such as personal loans, car loans, or some savings accounts. It offers predictability and simplicity, as the interest amount remains constant over time, making it easy for borrowers and savers to calculate and understand their financial commitments or returns. The formula for calculating simple interest is:

$$\text{Simple Interest (SI)} = P \times r \times t$$

Where  $P$  is the principal amount,  $r$  is the interest rate in decimal notation, and  $t$  is the time period usually in years.

### 3.7.2 Compound Interest

Compound interest, in contrast, is calculated on the initial principal and also on the accumulated interest from previous periods. This means that interest in each period is calculated on a progressively larger amount, leading to exponential growth over time. The formula for compound interest is:

$$\text{Compound Interest (CI)} = P - P(1 + r)^t$$

Where  $P$  is the principal amount,  $r$  is the interest rate expressed in decimal form,  $t$  is the time it is compounded over (usually in years).

Compound interest is more advantageous for savers and investors compared to simple interest because it allows their money to grow at a faster rate. It is commonly used in savings accounts, fixed deposits, and investments such as bonds and mutual funds. The frequency of compounding (annually, semi-annually, quarterly, monthly, or daily) significantly impacts the amount of compound interest earned, with more frequent compounding leading to higher returns.

For borrowers, compound interest can be more expensive than simple interest, particularly in long-term loans such as mortgages and student loans. The interest costs accumulate more rapidly, increasing the total amount to be repaid. Therefore, understanding the implications of compound interest is crucial for effective financial planning and decision-making.

## Chapter 4

# Methodology

### 4.1 Basic Business Model

A general trade objective business has the primary goal of making a profit at the end of the trading period, be it in the form of assets or cash. Regardless of the form of profit, at the end of the transaction the profit is given a value of how much it is worth in monetary terms. If the business was to continue its operations in the next transaction period, they must possess some sort of capital which they will use for investment purposes, hence (ideally) make profit, and the cycle continues. This can be thought of as “the basic business model”, where the business owner starts with an initial capital to invest into the business, make some profit from its operations, and invest the remaining amount back into the business for the next cycle of transactions. Figure 4.1 shows this basic “model” of a business. This model can be modified to account for our scenario scenario of: when the business owner takes a loan from a bank to start his/her business and he/she may or may not have their own starting capital. The model will have two variants based on the two respective banking systems.

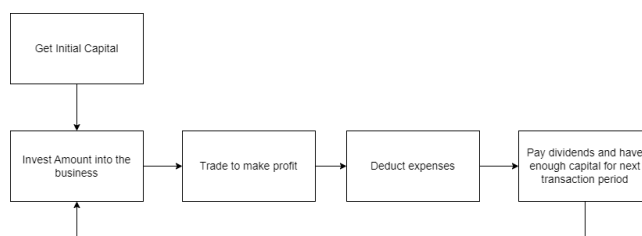


Figure 4.1: A basic business model

#### 4.1.1 The Interest Based Model

In this scenario, our assumption is that the bank gives out the loan based on compound interest. Here we have to be a bit careful about the frequency of compounding and the frequency of loan payment via installment by the business. For our study, the interest will be compounded over “ $n$  years” and the business pays in monthly installments to the bank. It should be noted that our study looks at fixed interest rate, and the monthly installments are constant, i.e. fixed monthly installments. For our case, the debt paid is treated as an operating expense, hence the monthly amount is recorded in the expenses section before net profit is calculated. Figure 4.2 shows this addition to the basic business model and how the operations change. Note that this cycle will continue until the debt has been settled.

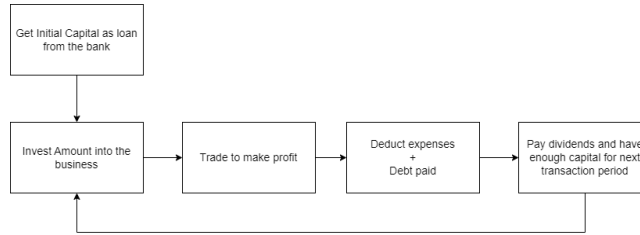


Figure 4.2: Interest based business model

#### 4.1.2 The Islamic (PLS Based) Model

For our study, we assumed the business operations to be a mix between *Musharakah* and *Mudarabah*, where the business owner (*Mudarib*) starts with no capital but provides the expertise and the bank (*Rab-ul-mal*) finances the initial operations. The net profit (or loss) gained after the transaction period is shared between the business owner and the bank until the debt (including the Bank Fee) owed to the bank has been paid. During the operations of the business, the bank and the business share the profit or loss incurred. Figure 4.3 shows the modified version of the basic business model to account for this operation.

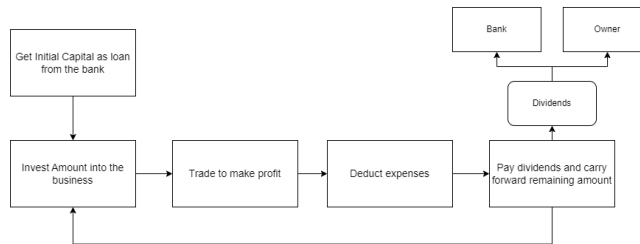


Figure 4.3: PLS based business model

## 4.2 Model to Algorithm Conversion

Based on the business models above, we can model the basic operations of a business under the “loan scenario”. There will be two isolated cases in which one uses the Interest Based Banking and the other uses Islamic (PLS Based) Banking. The owner will take a loan  $\psi$  which when the interest (for interest based banking)  $B_I$  or the profit (for PLS based banking)  $B_F$  is added totals  $\lambda$ , from the bank. If interest is used, then it is assumed to be compounded over a time period of  $T$  years. The amount that is used to reinvest into the business,  $C_R$ , is taken from the loaned amount  $\psi$ . This amount is then added to the current capital  $C_C$  of the business, resulting in the total investment amount of  $I$  for that period. The business makes a gross profit of amount  $P$  with a profit margin of  $\rho$ . After deducting the expenses  $E$  from the gross profit, the resulting net profit is given by  $P_{\text{Net}}$ . Depending on the type of banking system used, the business will either pay the dividend amount to the bank whose share in the equity is of amount  $B_S$  (if PLS banking) or will deduct the loan amount paid as an expense (if interest based banking). The business owner can decide to take out their share of the dividend  $D$  from the net profit. Note that  $B_S = (1 - D)$ . The current capital  $C_C$  is then recalculated at the end of the business month and the new amount is carried forward. The above set of transactions can be modelled via algorithm 1.

---

**Algorithm 1** Business Operation Algorithm

---

```
 $C_C \leftarrow \varphi$  at  $t = 0$   
 $C_I \leftarrow \psi$  at  $t = 0$   
  
if Banking System = PLS then  
     $\lambda \leftarrow \psi(1 + B_F)$   
else  
     $\lambda \leftarrow \psi(1 + B_I)^T$   
end if  
  
 $L \leftarrow \lambda$  at  $t = 0$   
  
while  $L > 0$  do  
     $C_I \leftarrow C_I - C_R$   
     $I \leftarrow C_R + C_C$   
     $P \leftarrow \rho \cdot I$   
  
    if Banking System = PLS then  
         $P_{\text{Net}} \leftarrow P - E$   
         $L \leftarrow L - B_S \cdot P_{\text{Net}}$   
         $P_{\text{Net}} \leftarrow P_{\text{Net}} - (B_S \cdot P_{\text{Net}})$   
    else  
         $P_{\text{Net}} \leftarrow P - (E + L_B)$   
         $L \leftarrow L - L_B$   
    end if  
  
     $C_C \leftarrow C_C + I + (1 - D) \cdot P_{\text{Net}}$   
end while
```

---

From the algorithm, it can be noted that variables  $C_C$ ,  $C_I$  and  $L$  are updated in each iteration, where an iteration is a time step. Therefore, these variables, as well as the others, can be thought to have recurrence relation with time-steps. As such, the algorithm can be rewritten in a recursive form, following the notation where  $C_I$  at time  $t$  will take the form  $C_t^I$ , at  $t + 1$  the form  $C_{t+1}^I$ , and so on. Algorithm 2 shows the rewritten form. This algorithm can be used for the time series analysis to look into the growth or decay of the business in general, as well as the nature of the debt incurred by the business. It can be noted that the variable  $C_C$  models the capital of the business, which can be used as a metric for the business's growth. A recursive set of functions can be quite complicated on their own to manipulate or use for analytical purposes. Therefore, it may be well suited to express them in their explicit form. The resulting model will then be expressed in terms of "pure, continuous functions" with respect to variable the time variable  $t$ . The output of the model will have functions *wrt.*  $t$  like  $C_t^C \rightarrow C_C(t)$ ,  $I_t \rightarrow I(t)$ ,  $L_{t+1} \rightarrow L(t + 1)$ , and so on. We can start this off by first focusing on the functions that we will actually

use for the purposes of our metrics for evaluating both the banking systems. In our case, we need be only concerned with functions  $C_C$  and  $L$ , to evaluate business growth and loan repayment period respectively. The following sections will discuss the PLS case and Interest case.

---

**Algorithm 2** Business Operation Algorithm in Recurrence Relation form

---

```

 $C_t^C = \varphi$  at  $t = 0$ 
 $C_t^I = \psi$  at  $t = 0$ 

if Banking System = PLS then
     $\lambda = \psi(1 + B_F)$ 
else
     $\lambda = \psi(1 + B_I)^T$ 
end if

 $L_t = \lambda$  at  $t = 0$ 

while  $L_t > 0$  at time  $t$  do
     $C_{t+1}^I = C_t^I - C_t^R$ 
     $I_t = C_t^R + C_t^C$ 
     $P_t = \rho \cdot I_t$ 

    if Banking System = PLS then
         $P_t^{\text{NetRaw}} = P_t - E_t$ 
         $L_{t+1} = L_t - B_t^S \cdot P_t^{\text{NetRaw}}$ 
         $P_t^{\text{Net}} = P_t^{\text{NetRaw}} - (B_S \cdot P_t^{\text{NetRaw}})$ 
    else
         $P_t^{\text{Net}} = P_t - (E_t + L_t^B)$ 
         $L_{t+1} = L_t - L_t^B$ 
    end if

     $C_{t+1}^C = C_t^C + I_t + (1 - D_t) \cdot P_t^{\text{Net}}$ 
end while

```

---



### 4.3 Case 1 – PLS Scenario

Let us start by simplifying the terms in  $C_C$ , specifically  $I$  and  $P_{\text{Net}}$  as these are terms that can be further expressed in “decoupled-terms” independent of other variables in the model. We can decompose the as follows:

$$\begin{aligned}
C_{t+1}^C &= C_t^C + (C_t^R + C_t^C) + (1 - D_t) \cdot (P_t - E_t) \\
&= 2C_t^C + C_t^R + k(P_t - E_t), & \text{where } k = (1 - D_t) = B_S \\
&= 2C_t^C + C_t^R + k(\rho I_t) - kE_t \\
&= 2C_t^C + C_t^R + k\rho(C_t^R + C_t^C) - kE_t, & \text{simplifying to} \\
C_{t+1}^C &= (2 + k\rho)C_t^C + (1 + k\rho)C_t^R - kE_t
\end{aligned} \tag{4.1}$$

We can convert equation 4.1 in its explicit form by expressing the recursive terms into differential terms, hence converting the entire expression into a first-order ODE. The equation below shows this.

$$\frac{d}{dt}C_C - (2 + k\rho)C_C = (1 + k\rho)C_R - kE \tag{4.2}$$

Similarly, we can convert our “loan-remaining” function  $L$  to its explicit form and express it in a first-order ODE as follows:

$$\frac{d}{dt}L - L = B_S E - \rho B_S (C_C - C_R) \tag{4.3}$$

Therefore, our PLS scenario can be (thought of as being) modelled by equations 4.2 and 4.3. Note that solving the equation  $L = 0$  gives the expected time period for the loan repayment. As it is evident that  $L$  is dependent on  $C_C$ , and we assume to use  $C_C$  as the growth metric of the business, the function  $L$  can be used by the bank to analyze the business’s expected performance and viability, and to carry out further risk analysis of the business.

### 4.4 Case 2 – Interest Scenario

In our Interest Based scenario, we can see from algorithm 1 and 2 that the difference in the two systems are only on how the loan is treated and deducted within the business – the loan is treated as an operational expense and forms part of the business’s total expenses, and it is paid in fixed installments instead of being a ratio of the net-profit. Therefore, it is evident that the business’s growth function is also modified as the net-profit function  $P_{\text{Net}}$  is changed, and the loan paid is independent of the net profit. Hence the following set of equations (4.4 and 4.5) can be deduced for the business’s capital and loan:

$$\frac{d}{dt}C_C - (2 + k\rho)C_C = (1 + k\rho)C_R - k(E + L_B) \tag{4.4}$$

$$\frac{d}{dt}L - L = -L_B \quad (4.5)$$

## 4.5 Purpose of Explicit Forms

Under normal circumstances, having a recursive set of equations for a time-series model is fine and works well to mimic realistic discrete time-steps. However, when the need to forecast a future value such as the state of the business or the status of the loan, one would need to run the model from the very beginning and iterate over each time-step. This is computationally expensive. And while it does hold true with the “essence” of a time-series model, it may be very inefficient when needing to make quick decisions and forecasts. Therefore, it is useful to have a continuous variation of the model. In the event of optimizing a certain parameter or a function, it is much more useful to have the explicit form of the model. It also helps when trying to determine analytically or empirically certain constants like the interest rate/bank fee, initial/starting capital, profit margin, and any other functions and/or parameters that may be of interest.

## 4.6 Model Simulation

During real-world testing and simulation, it may be unrealistic and computationally expensive to analytically solve the equations and compute their values. On one hand, we have differential equations which can take real inputs but is computationally expensive to solve analytically then use for simulations, and on the other hand we have a set of recursive equations which lack the precision of ODEs as they are restricted to discrete time-steps but are computationally “better”. So how can we achieve the “precision” of the ODEs but not have to deal with expensive computations? The answer lies in evaluating the equations numerically. For our purposes, we employ Euler’s method to numerically evaluate the values of the ODEs at the desired time value  $t$ . The Euler method is a straightforward numerical procedure for solving ordinary differential equations (ODEs) with a given initial value. It is a first-order method, which means it approximates the solution using linear interpolation between points. The general form of the Euler method for an ODE is given by the following expression:

$$y_{n+1} = y_n + hf(t_n, y_n)$$

Where  $y_n$  is the value of the function at the current step,  $h$  is the step size,  $f(t_n, y_n)$  is the derivative of the function at the current step, and  $t_n$  is the current time. In this case the function of our interest is  $C_C$  which we would like to evaluate. We also need its derivative  $C'_C$ , but we know this from equations 4.2 and 4.4 for our two cases respectively. Hence, the algorithm 3 can be used to achieve a “higher” precision than the recursive model and evaluate real-valued inputs. Note that the algorithm assumes PLS scenario as an example.

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**Algorithm 3** Numerical Solution using Euler's Method of PLS Scenario

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 $t_{space} \leftarrow [0...t]$  with  $N$  steps $h \leftarrow t_{space}[1] - t_{space}[0]$  $C_C$  = an array of size  $N - 1$  $C_C[0] = \varphi$ **for**  $n = 0$  to  $N$  **do** $C_C[n + 1] = C_C[n] + h((2 + k\rho)C_C[n] + (1 + k\rho)C_R - kE)$ **end for**

---

Algorithm 3 can be modified to include the fixed payment  $L_B$  by adding it to the expense variable  $E$  in the algorithm to achieve the Interest based scenario. In a similar manner, one can also obtain values of the loan function of the PLS scenario numerically using Euler's method with the following algorithm:

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**Algorithm 4** Numerical Solution of Loan Function of PLS Scenario

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 $t_{space} \leftarrow [0...t]$  with  $N$  steps $h \leftarrow t_{space}[1] - t_{space}[0]$  $L$  = an array of size  $N - 1$  $L[0] = \lambda$ **for**  $n = 0$  to  $N$  **do** $L[n + 1] = L[n] + h(L[n] + B_S E - \rho B_S (C_C[n] - C_R))$ **end for**

---

It can be noted that algorithms 3 and 4 are worked on in terms of arrays. The reason being, for analysis purposes, one may need to plot graphs of the trends of the simulations for the capital function. As such, it will be easier to have the corresponding values of  $C_C$  ready to plot with their respective values from  $t_{space}$ . Note that the value of interest of time  $t$  is the last element of the array  $C_C$ . These algorithms assume that we have the parameters  $\rho$ ,  $C_R$ ,  $E$  and  $B_S$  are kept constant. But it is also easy to infer that should the aforementioned variables be treated as time-dependent functions, then the parameters would take their corresponding values at the  $n^{th}$  time-step,  $t_n$  from the  $N$ -stepped time-space array  $t_{space}$ . Should one be only interested with single-valued output from this iterative algorithm, then they can simply replace the values of the original variable with the new computed value.

## Chapter 5

# Experiments

State the experiment parameters and their values. Include the assumptions made and why. Plot the graphs of a few set of experiments. Use both recursive and explicit equations.

## Chapter 6

# Discussion

Conclude the research and include further studies

## Chapter 7

# Conclusion

Conclude the research and include further studies

## Chapter 8

# Appendix

## Appendix A

Include the Python codes for the classes here.