Indian Institute of Technology Delhi

MSL310: Financial Institutions and Markets

UPI: Reshaping Digital Payments

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Contents

Acronyms

NEFT National Electronic Fund Transfer

POS Point of State

RTGS Real Time Gross Settlement

SWOT Strengths, Weaknesses, Opportunities, Threats

RBI Reserve Bank of India

NPCI National Payments Corporation of India

IPO Initial Public Offering

NSDL National Securities Depository Limited

UPI Unified Payments Interface

PSPs Payment Service Providers

MDR Merchant Discount Rate

POS Point Of Sale

USSD Unstructured Supplementary Service Data

AePS AADHAR enables payment system

PPIS Prepaid Payment Instruments

DBT Direct Benefit Transfer

CAGR Compound Annual Growth Rate

SMEs Small and Medium Enterprises

KYC Know Your Customer

P2P Peer to peer

P2M Peer to merchant

DeFi Decentralized Finance

COVID Corona-Virus Disease

IMPS Immediate Payment System

Objectives

This case study aims to examine the evolution and potential of the UPI, managed by the National Payments Corporation of India (NPCI). The defined objectives are as follows:

- To trace the historical development of **UPI** and assess its current standing in the milieu of digital payments.
- To scrutinize transactional data spanning the fiscal years **2016 - 2023**, thereby charting the ascension of the **UPI** framework.
- To identify and discuss the catalysts that have propelled the recent advancements of **UPI**.
- To conduct an exhaustive Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis of the **UPI** infrastructure.
- To test and validate the hypothesis that **UPI** transactions in the digital retail market will cross 85% by volume and 65% by value in the coming years, thereby supporting the hypothesis that: ***India is on the cusp of a cashless economy, with UPI poised to become the predominant force in the digital payment landscape***

Background

2.1 History of UPI

In 2012, the Reserve Bank of India (RBI) outlined a four-year vision statement emphasizing the commitment to developing a secure, efficient, and inclusive payment and settlement system in India. This initiative also aligned with the Green Initiative to reduce paper usage in domestic payments. Under the guidance of the RBI, the NPCI became the primary entity tasked with creating a new payment system. The Unified Payments Interface (UPI) was officially launched in 2016, operating on a four-pillar push-pull interoperable model. This model involved front-end Payment Service Providers (PSPs) for remitters/beneficiaries and back-end banks settling the monetary transactions. Recognized as a successful deep-tech financial innovation, UPI gained widespread acclaim, prompting global interest.

2.2 Legislation and Regulatory Framework

In April 2009, the establishment of the NPCI aimed to standardize and integrate all payment mechanisms in India, particularly focusing on retail payments. By March 2011, the RBI observed a low frequency of non-cash transactions among individual citizens, prompting the need for a more uniform and accessible payment system. With only six non-cash transactions per year per individual, and 10 million retailers accepting card-based payments, the gap in financial inclusion and the prevalence of black money and corruption in cash transactions became evident.

2.3 Legislative Developments and Economic Impact

Starting from January 2019, UPI gained popularity as a payment option for Initial Public Offering (IPO). Transaction limits saw progressive increases, reaching `Rs.500,000` for Retail Direct Scheme and IPO applications by December 2021. To ensure the economic feasibility of UPI for payment companies, the RBI is considering the implementation of a Merchant Discount Rate (MDR) on future UPI transactions. The RBI's 2022-23 financial year policy proposed a cardless cash withdrawal facility from ATMs using UPI-based QR codes. Collaborative efforts, such as the launch of **VoiceSE** by **ToneTag** in partnership with National Securities Depository Limited (NSDL) Payments Bank and the NPCI, further extended UPI's accessibility, allowing `400 million` feature phone users to make payments using voice commands in multiple languages. The year 2023 witnessed UPI usage expanding beyond metro areas, with a significant percentage of users hailing from Tier-2 cities and surrounding regions, according to **Redseer Strategy Consultants**.

Literature Review

UPI has been a revolutionary step in the digital payments sector in India, with a significant surge in usage post the Corona-Virus Disease (COVID)-19 pandemic. Here are some of the conducted research in this very field

3.1 Growth Post-COVID

This study explores the significant increase in the use of UPI applications in India following the COVID-19 pandemic. It emphasizes the role of UPI in facilitating a cashless economy and contributing to India's rapid development as a digital economy. The research indicates that the pandemic has accelerated the adoption of digital payments, with UPI at the forefront of this transformation, offering a convenient and secure method of transaction that aligns with the social distancing norms.[1]

3.2 Transaction Analysis

In this study, the authors analyze the remarkable growth of UPI transactions in India. The paper notes that in March 2023, there were over `8.6 billion` UPI transactions valued at over `INR 12.08 trillion`. This growth is attributed to the ease of integration of UPI with various payment apps and its convenience, which has led to widespread adoption and a significant shift in the digital payment landscape in India.[12]

3.3 Digital Transformation

This paper discusses the increasing popularity of UPI as a payment option and its role in the digital transformation of India's economy. The study highlights the rising adoption rates and usage of UPI, projecting a future of continued growth and innovation. It suggests that UPI's user-friendly interface and interoperability are key factors driving its success.[14]

3.4 Systematic Review

This study provides a comprehensive analysis of the factors contributing to the growth of UPI. It reveals a consistent year-on-year increase in UPI transactions, particularly in the small-ticket Peer to merchant (P2M) sector. The review projects that **DIGIFIED** P2M payments will grow to `USD 1.1 trillion` by 2025, emphasizing UPI's significant impact on India's journey towards a cashless society.[13]

SWOT

4.1 Strengths

- **High Adoption Rate:** The UPI has witnessed rapid adoption since its launch, becoming one of the most widely used payment systems in India. This widespread adoption demonstrates its appeal to both consumers and businesses.
- **Convenience and Accessibility:** The UPI offers a convenient and user-friendly payment experience, allowing users to make instant transactions using their smartphones. Its interoperability across various banks and payment service providers enhances accessibility.
- **Cost-Effective:** UPI transactions typically have lower transaction costs compared to traditional payment methods like credit cards and National Electronic Fund Transfer (NEFT) transfers. This makes it an attractive option for both individuals and businesses, particularly Small and Medium Enterprises (SMEs).
- **Innovation and Continuous Improvement:** The NPCI has demonstrated a commitment to innovation and continuous improvement in the UPI ecosystem. It regularly introduces new features and enhancements to meet evolving customer needs and stay ahead of the competition.

4.2 Weaknesses

- **Security Concerns:** Despite its popularity, the UPI is not immune to security threats such as phishing attacks, malware, and fraud. Instances of unauthorized transactions and data breaches have raised concerns among users about the security of their financial information.
- **Dependency on Internet Connectivity:** UPI transactions require a stable internet connection, which can be a challenge in areas with poor network coverage or during network outages. This dependency on internet connectivity limits the accessibility of the UPI in certain regions and situations.
- **Limited Merchant Acceptance:** While the UPI has gained significant traction among consumers, its acceptance among merchants varies. Some merchants, particularly smaller businesses, may not accept UPI payments due to factors such as lack of awareness, infrastructure, or reluctance to adopt new technologies.
- **Regulatory Challenges:** The regulatory environment surrounding digital payments in India is complex and subject to frequent changes. Compliance with regulations such as Know Your Customer (KYC) requirements and transaction limits can be burdensome for both users and service providers.

4.3 Opportunities

- **Continued Growth in Digital Payments:** India's digital payments market is expected to continue growing rapidly, driven by factors such as increasing smart-

phone penetration, government initiatives promoting cashless transactions, and a growing acceptance of digital payments among consumers and businesses. This presents a significant opportunity for the UPI to further expand its user base and transaction volumes.

- **Expansion into New Use Cases:** The UPI has the potential to extend beyond Peer to peer (P2P) and P2M transactions to other use cases such as bill payments, online shopping, and international remittances. By diversifying its offerings, the UPI can capture a larger share of the digital payments market and increase its relevance in the lives of users.

- **Collaboration with Fintech Companies:** Collaborating with fintech companies and startups can help the NPCI enhance the UPI ecosystem by introducing innovative features, targeting specific customer segments, and addressing unmet needs. These partnerships can drive product innovation and expand the UPI's reach into new markets and demographics.

4.4 Threats

- **Competition from Alternative Payment Systems:** The UPI faces competition from alternative payment systems such as digital wallets, mobile banking apps, and other platforms offered by banks and fintech companies. These competitors may offer similar features, better incentives, or exclusive partnerships, posing a threat to the UPI's market share.

- **Technological Disruptions:** Rapid advancements in technology, including blockchain, cryptocurrencies, and Decentralized Finance (DeFi), could disrupt the traditional payments landscape and challenge the relevance of existing payment systems like the UPI. The NPCI must stay abreast of these developments and adapt its strategy accordingly to remain competitive.

- **Regulatory Changes and Compliance Burdens:** Changes in regulations governing digital payments, including taxation, data privacy, and cybersecurity requirements, can create compliance burdens for UPI service providers and increase operational costs. Adapting to these regulatory changes while maintaining user trust and satisfaction is essential to mitigate potential threats.

- **Cybersecurity Risks:** As digital payment systems become increasingly interconnected and sophisticated, they also become more vulnerable to cybersecurity threats such as hacking, data breaches, and ransomware attacks. A major security breach or downtime in the UPI system could undermine user confidence and lead to reputational damage for the NPCI.

Factors Involved

5.1 Retail Payment

Retail transactions are referred to as transactions having low-value denominations and high in number.
A variety of characteristics are exhibited by retail payment systems. They deal with numerous **low-value individual payments** in particular. Retail payments differ from large-value transactions. They are used in a wider range of circumstances than inter-bank transactions, namely in-person payment using Point Of Sale (POS) computers and payment over the Internet. Next, in comparison to large-value transactions, retail payments use a wide range of payment instruments, including both paper-based and digital methods. Third, unlike large-value payments, which rely significantly on central bank-operated NEFT and Real Time Gross Settlement (RTGS) systems, retail payments are typically handled by a variety of payment service providers such as banks, post offices, FinTech companies, and so on.

5.2 UPI in India's Digital Payment Ecosystem

Digital Payment Ecosystem consists of the payer (initiator), receiver (accepter), acquirers (receiver's bank), and issuers (payer's bank). A digital payment ecosystem can be referred to as a system that connects all of these parties through a paperless mode of payment or fund transfers. As per the RBI database, India's digital payment ecosystem includes various digital payment instruments such as **Banking cards** (Debit/Credit Cards), Unstructured Supplementary Service Data (USSD), AADHAR enables payment system (AePS), Internet Banking NEFT, Immediate Payment System (IMPS), and RTGS, M-Wallets, Prepaid Payment Instruments (PPIS), and Unified Payment Interface (**UPI**). According to the most recent RBI data of **FY 2022-23**, UPI accounts for **77.43%** of all retail digital payment transactions.
UPI was developed to facilitate payment systems in retail digital payment transactions, and it now accounts for more than half of the total transactions performed in the digital payment ecosystem. Due to the maximum ceiling restriction of `Rs.200000` in the UPI payment system, NEFT, and RTGS continue to dominate in terms of volume, accounting for 89.29% of digital transactions during May 2021 amounting to 104.52 trillion rupees.

5.3 Demonetization[2]

On November 8, 2016, in an unprecedented move, Prime Minister Narendra Modi announced the demonetization of all `INR 500` and `1000` bills. At a total of INR 15.4 trillion, these bills constituted 86.9% of the value of total currency in circulation.
India has long been a cash-based economy, but in recent years, the country has been in the process of transitioning towards a cashless society. In November 2016, this transition was accelerated when 87% of the country's paper currency by value was demonetized. The macroeconomic merits of demonetization remain up for debate, but the policy shock did provide India a golden opportunity to replace legacy systems with ones that could

interface with new IT platforms and the country's national ID database, Aadhaar. Although digital payment remains relatively infrequent for now, total digital payments are expected to reach USD 500 billion by 2020, ten times the level in 2016. The government has encouraged this transition by linking public transactions such as Direct Benefit Transfer (DBT) to e-payment services through Aadhaar.
Since the announcement of demonetization, there has been a surge in digital transactions via credit/debit cards, e-wallets, and mobile phone applications. Demonetization acted as a catalyst towards a digital payments ecosystem. To further accelerate this process, the central government has announced a package of incentives and measures for the promotion of digital and cashless transactions.
Prior to demonetization, non-cash payments in India were facilitated by a wide array of different platforms and technologies supported by the banking industry and the Reserve Bank of India. The need for an easier, simpler way to make payment has recently caused e-wallets to become dominant at the expense of the banking system. E-wallets represented an improvement over prior systems, which are access-restricted (not everyone has credit/debit cards), complicated (requiring entering net banking/card details for every transaction), and experience high failure rates due to complicated processes.

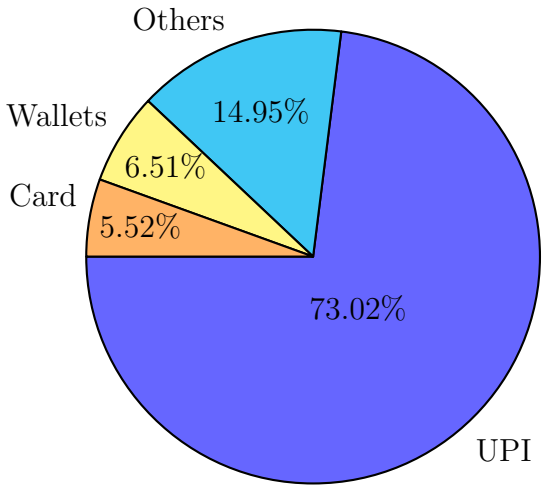
5.4 COVID-19[8]

The COVID-19 pandemic significantly accelerated the growth of UPI in India, as consumers and businesses increasingly turned to digital payment methods to minimize contact and curb the spread of the virus. With the onset of the pandemic, there was a marked surge in the adoption of UPI due to its ease of use and the safety of contactless transactions, pushing monthly UPI transactions to exceed 2 billion for the first time in October 2020. As businesses of all sizes, particularly small and medium-sized enterprises, adopted UPI to facilitate seamless and contactless transactions, the merchant base for UPI expanded dramatically. This period also saw the introduction of innovative features such as **UPI AutoPay**, which enhanced convenience by allowing users to manage recurring payments more efficiently.
Recognizing the potential of digital payments to reduce physical contact, the Indian government and regulatory bodies encouraged the use of UPI, even integrating it into the payment systems of government services. This was complemented by UPI's increasing integration into e-commerce and online platforms, which further solidified its status as a preferred method of payment during the pandemic. Despite facing initial challenges due to lockdowns and economic disruptions, the digital payments sector, led by UPI, showed remarkable resilience and adaptability, maintaining robust and secure transaction processes. This transformation catalyzed by the pandemic not only accelerated the penetration of UPI across Indian society but also set the stage for a more digitally empowered economy, establishing a trend that is likely to continue in the post-pandemic era.

Data Analysis

6.1 UPI Statistics at a glance (2016-2021)

The UPI service was launched by NPCI in 2016 with the participation of 21 banks. During the financial year 2016 – 17, the contribution of UPI in digital payment services was only about 63 lakh transactions. At present, that has skyrocketed hugely (6.1). According to NPCI data, UPI railroad registered **13.44 billion** transactions in March 2024, one of the most ever in a single month since it began operations in August 2016. RBI reported, that due to the requirement of social distancing during the coronavirus pandemic, contactless payments were preferred over cash payments, even though the value and volume of the latter were considerably down due to the slowdown in economic activity before the outbreak. The number of transactions on the UPI platform, as well as overall retail digital payment transactions, has risen exponentially, in value and size of transactions. The comparison of UPI with other modes of payment is shown in 6.1



(a) Transaction Volume

Figure 6.1: Comparison of different Payment Systems as of `FY 2022-23` [7]

6.2 Progression of UPI in Retail Digital Payment

UPI is considered to be more user-friendly and safer than other online banking or digital payment methods. As a result, one can start using UPI to send and accept payments instantly. People are taking behoof of the UPI payments which is encouraging businesses to adopt digital payment acceptance. The usage statistics of UPI platform for retail payments from 2016-2024 is shown in 6.1 below.

Year	Total Financial Txn Volume (in Mn)	UPI Txn Volume (in Mn)	% of UPI Volume to Total	Total Financial Txn Value (in Bn)	UPI Txn Value (in Bn)	% of UPI Value to Total
2016 - 17	7138.40	17.86	0.25%	96626.07	69.47	0.07%
2017 - 18	9857.60	915.23	9.28%	113552.76	1098.32	0.97%
2018 - 19	16806.25	5353.40	31.85%	136719.23	8769.70	6.41%
2019 - 20	26493.23	12518.62	47.25%	160923.65	21317.30	13.25%
2020 - 21	37512.73	22330.65	59.53%	165529.97	41036.54	24.79%
2021 - 22	65299.45	39440.44	60.39%	236828.28	68294.38	28.83%
2022 - 23	105412.75	81622.10	77.43%	321919.49	138691.68	43.08%

Table 6.1: Retail Digital Transactions (w.r.t. Volume and Value) for 2016 - 2023 [7]

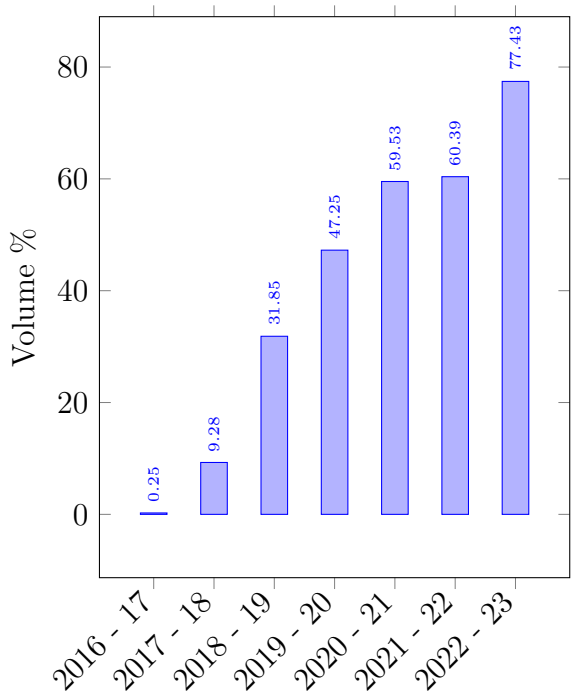


Figure 6.2: UPI Transaction Volume %

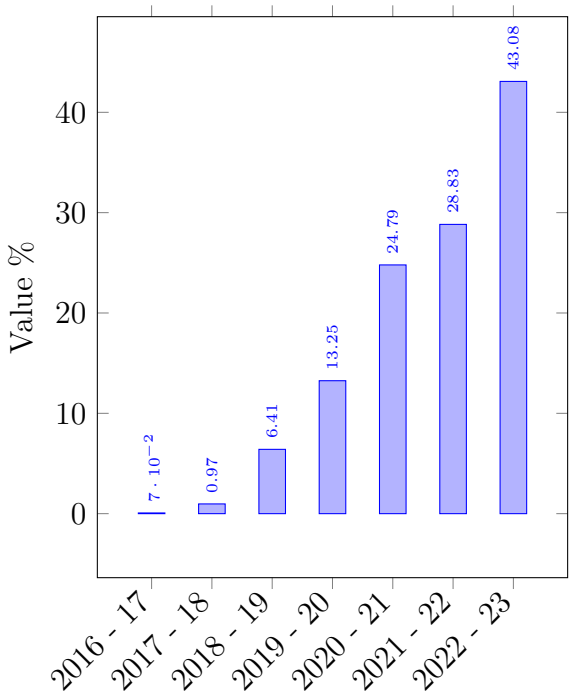


Figure 6.3: UPI Transaction Value %

Methodology

The project is descriptive in nature. It employs an exploratory research method to gather the necessary data from secondary sources such as published **research works, RBI reports**, government reports, etc. This data will be utilized to analyze and test our **hypothesis** that **India is heading towards a cashless economy, with UPI poised to become the predominant force in the digital payment landscape**. The methodological approach is outlined as follows:

1. Obtain data on the volume and value of UPI transactions in India for the past decade and plot graphs for the **value and volume** of UPI transactions as a percentage of the total digital retail transactions from **2016-2023**.

2. Calculate the **Compound Annual Growth Rate (CAGR)** metric for UPI Transaction Volume and Value.

3. Consider relevant variables like Internet Penetration, Smartphone Usage, Digital Literacy, etc., and perform a correlation analysis with respect to UPI transaction value and volume to observe how strongly these factors have influenced India's transition to a cashless economy.

4. Develop a **predictive model** by combining the above data to test our hypothesis. The steps are as follows:

   (a) **Feature Projection**: Compute future values for certain features (e.g., Internet Penetration, Smartphone Usage, Digital Literacy) over a specified number of years (`n`-years). This is achieved by initializing a matrix with current values and iteratively updating each feature by multiplying the previous year's value by 1+the respective growth rate. These computations produce a matrix (X_{test}) that represents projected values of each feature from the last known value onwards for the next `n`-years.

   (b) **Data Preparation**: Create X_{combined} which is formed by vertically stacking the training data (X_{train}) and the projected data (X_{test}). This combined dataset is then normalized using `StandardScaler`. Normalization adjusts the data to have a mean of **zero** and a standard deviation of **one**.

   (c) **Machine Learning Application**: The normalized combined data is split back into training and testing sets based on the original X_{train} size. Two linear regression models are employed for model fitting and prediction (model1 for target variable y_1 and another instance for y_2). Each model is trained on the normalized training data with corresponding target values (y_1 or y_2). The models are then used to predict the outcome for both the training period and the forecast period. Predictions are printed for the training range (2016-2023) and the test period (2023-24 onwards).

Results[1]

The variables to be predicted are: %age of UPI transactions **by Volume** (y_1) and **by Value** (y_2) in **Retail Digital Markets**

8.1 Feature Details

The feature variables used which largely influences this are: **Internet Penetration** (x_1), **Smartphone Usage** (x_2), **Digital Literacy** (x_3). The yearwise values are as follows:

	Internet Penetration[6]	Smartphone Usage[11]	Digital Literacy[4]
2016-17	17	23	20
2017-18	18	29	28
2018-19	20	35	33
2019-20	30	46	35
2020-21	43	54	38
2021-22	46	61	41
2022-23	52	66	52

Table 8.1: Year-wise value of the feature variables

The correlation values of these variables as calculated w.r.t the values stated in 8.1 and 6.1 are stated in the table below:

	UPI Txn Volume (Mn)	UPI Txn Value (Bn)
Internet Penetration	0.887245	0.897441
Smartphone Usage	0.870888	0.879256
Digital Literacy	0.917663	0.920279

Table 8.2: Correlation Values with UPI Txn Volume

As it can be seen above, these three variables are highly correlated with the **UPI Txn Volume** and **Value**. So we use these as our primary features for prediction.
The feature values for the next few years is simply obtained from their respective predicted growth rates as stated by official sources.

Category	Growth Rate	Estimation Criteria
Internet Penetration[5]	0.087	From 14% in 2014 to over 52% in 2024, approximately 8.7% annual growth rate
Smartphone Usage[10]	0.060	Expected to increase at a CAGR of 6% from 2021 to 2026
Digital Literacy[4]	0.034	Assuming a linear growth from 15% in 2018 to 65% in 2023, approximately 3.4% annual growth rate

Table 8.3: Growth Rates of features

[1]The Python Notebook containing all the computation can be found here: Click Here

8.2 Regression

As stated in the previous chapter, we now perform regression with x_1, x_2, x_3 as the features. We will train two models w.r.t y_1 and y_2 based of the seven financial years from **2016-2023** The final plot of the predicted y_1 and y_2 values are as follows:

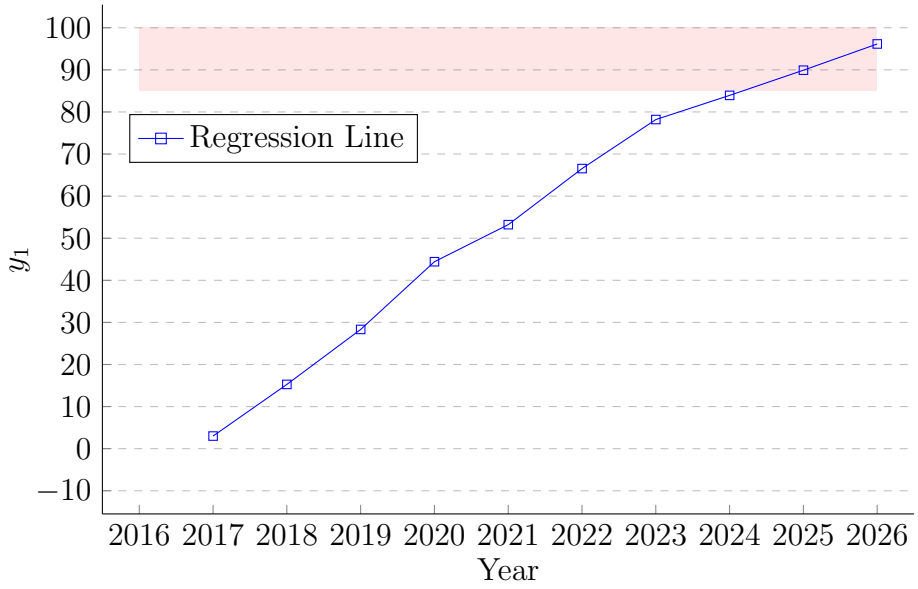


Figure 8.1: Year-wise Predictions of % by Volume (y_1)

In 8.1, the threshold level taken for significant market capture is **85%**. As per the prediction by the model, this will be achieved by the end of **FY 2024-25**

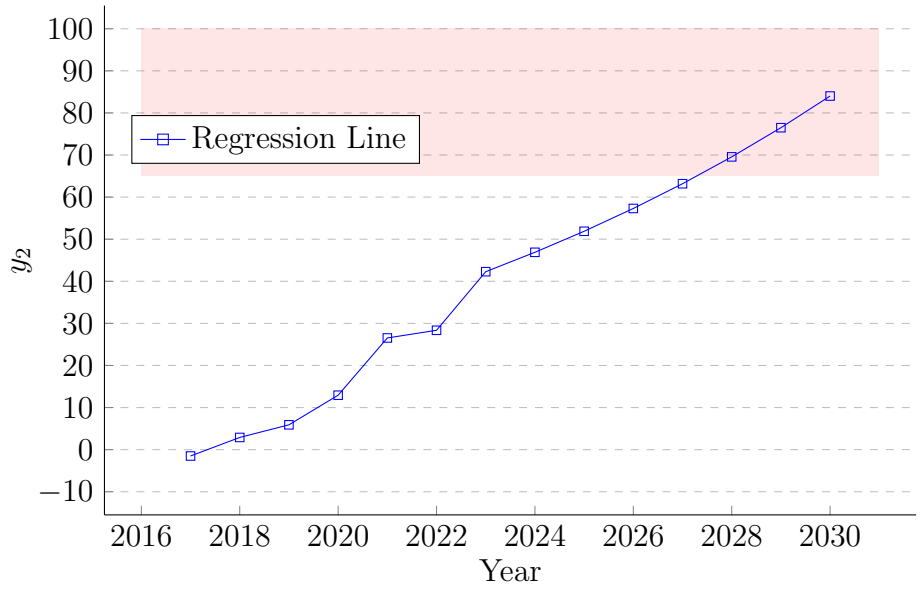


Figure 8.2: Year-wise Predictions of % by Value (y_2)

In 8.2, the threshold level taken for significant market capture is **65%**. As per the prediction by the model, this will be achieved by the end of **FY 2028-29**

Conclusion

The analysis and data presented underscore a significant shift towards a digital payment infrastructure in India, particularly emphasized by the rapid adoption and growth of the Unified Payments Interface (UPI). From its inception in 2016, UPI has surged to account for a substantial portion of the retail digital transactions by both volume and value, showing an impressive compound annual growth rate. Factors such as increased internet penetration, higher smartphone usage, and improved digital literacy have been closely correlated with this surge in digital transactions, reflecting a broader shift in the socio-economic landscape of India towards digitalization.

The strategic initiatives like demonetization and governmental pushes towards digital literacy and infrastructure, especially during events like the COVID-19 pandemic, have accelerated this trend. The predictive models, based on regression analyses using key variables like internet penetration, smartphone usage, and digital literacy, forecast a continuation of this trend, suggesting that UPI and other digital payment methods will increasingly dominate the financial transactions landscape in India.

As India progresses towards a cashless economy, the implications are profound, affecting everything from daily transactions of the common man to the operational modalities of large businesses. This shift not only enhances transaction efficiency but also broadens financial inclusion across the country's diverse population, contributing significantly to economic modernization and growth. The sustained focus on improving digital infrastructure and literacy is likely to further cement the role of digital payments, making them a cornerstone of India's economic framework in the coming years.

In this context, as per the predictive model, the volume of payments is expected to dominate the retail market by the end of **FY 2024-25** and the value of payments by the end of **FY 2028-29**, as shown in Figure 8.1 and Figure 8.2. These projections are not just mere statistics but represent the potential for a transformative change in the Indian economy, signaling a move towards a more inclusive and technologically advanced financial ecosystem.

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List of Tables

List of Figures