

Digital Transformation: The Economic Impact of Technology Adoption

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Abstract

With technological advances being made rapidly, the world has also seen rapid rates of technological adoption. Better tools and techniques have changed the pace of production and consumption to such an extent, that compared to the scenarios two decades ago, the present economic world seems super-charged. Focusing on highly prevalent and economically booming technologies like digital payments, blockchain, cryptocurrency, etc., we show how new technologies can impact economies, taking India as an example in various cases. Further, with data-driven evidence, we present several ways in which each technological advancement can affect society, and conclusively find positive correlations and impacts of technological adoption. Additionally, we provide theoretical conjectures on how to improve the positive impacts of the mentioned technologies with proposals to the monetary and fiscal policies, along with regulatory measures. In essence, the adoption of more technological advancements shall bring better utility to human life, and greater flow of money in the economy for both the producer and consumer. With proactive yet regulated incorporation into the country's policies, we hypothesize that digitization shall have a positive overall effect on the economy.

Keywords: digitization, economic growth, cryptocurrency, digital payments, market capital, monetary policy, fiscal policy.

1 Introduction

A significant technical shift called “digital transformation”, sometimes known as “digitalization”, is currently taking place. How nations accept new technologies will determine the course of the next several decades. It will boost economic competitiveness and efficiency,

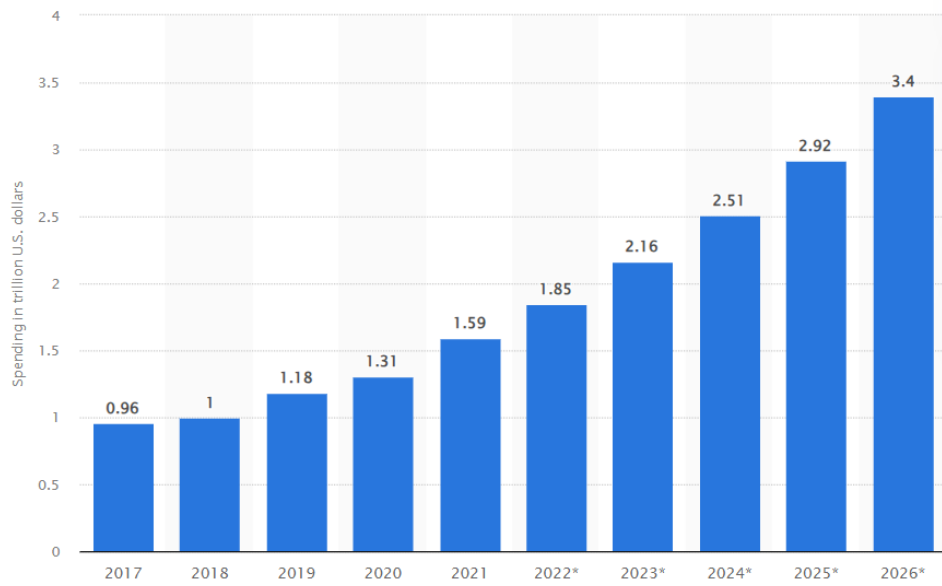


Figure 1: Spending on digital transformation technologies and services worldwide from 2017 to 2026 ; Source: “Spending on digital transformation technologies and services worldwide from 2017 to 2026” (2023)

generate new ventures and goods, and solve issues with expanding financial inclusion, enhancing governance, and lessening inequality. This move to a digital economy, a by-product of adopting new technologies, is marked by the widespread use of technology in all areas of life. Using digital tools and platforms has become a sign of economic growth in all fields, established, and new. Moreover, this change can be seen in rich as well as developing economies, acting as a significant factor in practices helping developing countries grow.

One of the main effects of digital transformation is the vast increase in openness and accessibility of knowledge. People and companies alike have been given more power by the widespread availability of the internet and other digital technologies, hence, this has levelled the playing field by providing greater access of the economy to the previously restricted and downtrodden. Now, small businesses of the scale of only one person can also reach customers all over the world, improving the state of producers and sellers. Likewise, since customers now have a broader range of goods and services available, they have more information and options for their needs. As a preliminary data-driven evidence to show prevailing sentiments regarding technological adoption, a survey by the European Central Bank (ECB) shows a large number of positive responses towards investment and utilization of up and coming technologies (Fig. 3). Additionally, ECB’s survey also captures existing sentiments in the data visualized in Fig. 2. We find positive predictions regarding company’s capitalization

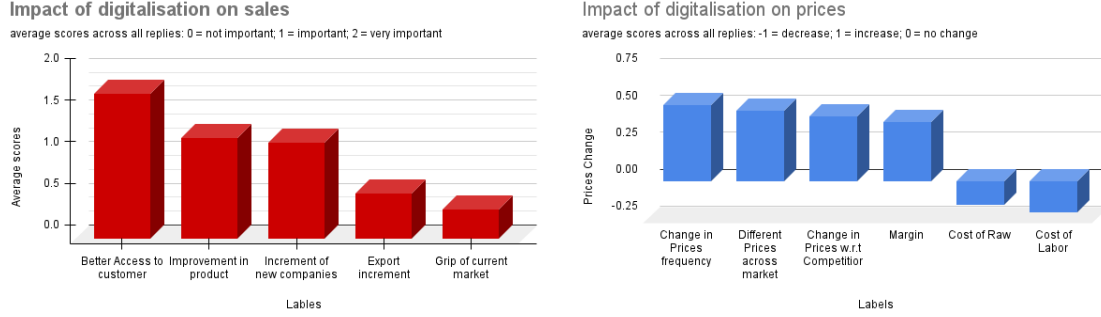


Figure 2: Sources: Elding and Morris (2018).

opportunities, as well as areas like employment of skilled labour, quality of product, access to new consumer bases, and overall profit margin. Therefore, the impact of digitization can be theoretically seen to be positive on both producers and consumers, however, these impacts must be grounded in data-driven evidence and robust analysis. To this end, we present various technologies in this paper which are seeing rapid adoption, as well as industrial research and development to make the even more feasible for real-world usage. Notably, these tools shall also be described with the impacts that they bring on the national economy that best fall under their lenses.

2 Data

We investigate two primary technologies and their impacts on the economy:

1. *Cryptocurrencies* such as BitCoin, Ethereum, etc.
2. *Digital payments* such as UPI.

As a useful practice, we establish a time-frame of the financial years of 2014 to 2021, and use the GDP data of India as a steady reference to other data regarding technological adoption of cryptocurrencies and digital payments. This is presented in Table 1. The data used to analyze each respective technology is presented in the following subsections.

2.1 Data for cryptocurrency

The data used to quantify the impact of cryptocurrency on economy in our work is

Year	GDP Nominal (Current USD)	GDP Real (Inflation adj.)	GDP change
2022	\$3,385,090,000,000	\$2,954,980,000,000	7.00%
2021	\$3,150,310,000,000	\$2,761,590,000,000	9.05%
2020	\$2,671,600,000,000	\$2,532,400,000,000	-5.83%
2019	\$2,835,610,000,000	\$2,689,210,000,000	3.87%
2018	\$2,702,930,000,000	\$2,588,970,000,000	6.45%
2017	\$2,651,470,000,000	\$2,432,020,000,000	6.80%
2016	\$2,294,800,000,000	\$2,277,270,000,000	8.26%
2015	\$2,103,590,000,000	\$2,103,590,000,000	8.00%
2014	\$2,039,130,000,000	\$1,947,830,000,000	7.41%

Table 1: A tabular representation of India’s GDP over the selected time-frame, used as a statistical reference in our methodology. Sources: “World Bank Database” (2023).

Country	Overall ranking	Centralized service value	Retail service value
India	1	1	1
Nigeria	2	3	2
Vietnam	3	4	4
United States	4	2	8
Ukraine	5	5	3

Table 2: The top five overall ranks for countries on the Global Crypto Adoption Index for 2023 with ranks in various additional verticals.

2.1.1 Global Crypto Adoption Index 2023

To first quantify the current state of adoption of blockchain and cryptocurrency-based technologies, we use the “Global Crypto Adoption Index” (2023). This ranks countries on the basis of their cryptocurrency usage, incorporation into existing infrastructure, and future potential. This shall present a foundation of understanding of how much India as a country is using cryptocurrency-based technologies, and can also be visualized in Fig.4

2.1.2 Custom Crypto Index v/s Gross Domestic Product (GDP)

By taking the top three cryptocurrencies in India, namely BitCoin (BTC), Ethereum (ETH), and Binance (BNB) and summing them up, we make a custom crypto index based on monthly value series from November 2022 to May 2023 for an up-to-date comparison. This is analyzed with a similar series for the GDP as given in the methodology.

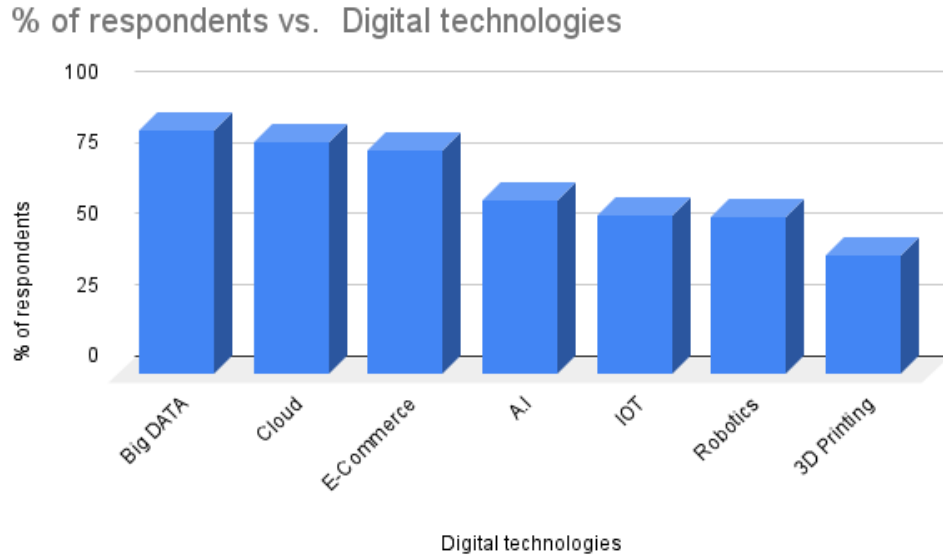


Figure 3: Investments in technologies by various companies. Sources: Elding and Morris (2018).

2.2 Digital payments

To evaluate the impact of digital payment technology, primarily UPI in India, we look at the following data. Each type of data is described with respect to its nature.

2.2.1 Volume, value, and bank adoption statistics

The extent of UPI adoption is useful to establish first, hence, we use data from the Nation Payment Corporation of India (“NPCI Statistics” (2023)) showing the volume of UPI transaction occurring yearly, juxtaposed with the value of the transactions and rate of banks being live on UPI.

2.2.2 Percentage contribution to GDP of various methods of payment

To evaluate the popularity as well as impact in terms of value of UPI, we use data showing a time series of percentage contribution of each method of transaction like CTS cheques, UPI, and cash. Specifically, we use a quantitative study from “RBI” (2023) containing yearly data showing what percentage of GDP a particular payment method yielded. This is done for each financial year from 2014-2015 to 2021-2022.

GROWTH IN CRYPTOCURRENCY VALUE RECEIVED

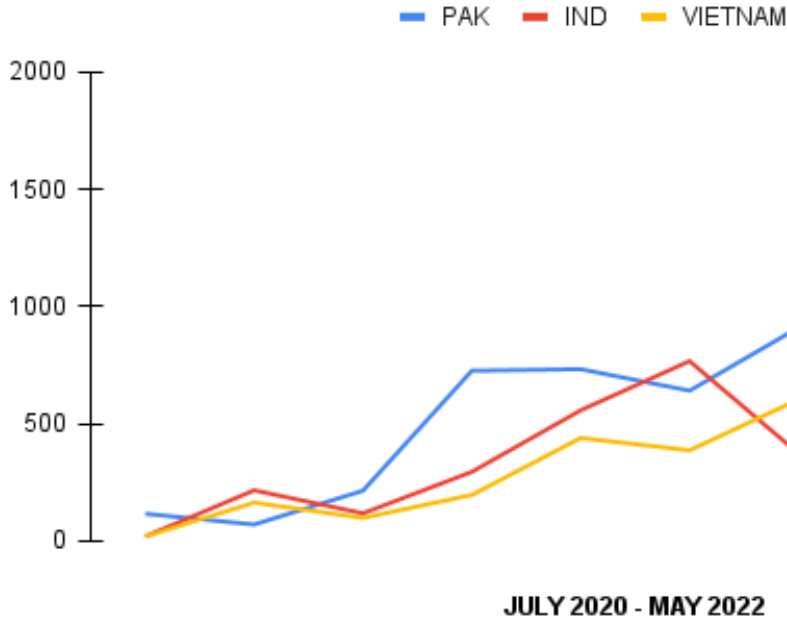


Figure 4: Countries by crypto value received from July 2020 to May 2022..

2.2.3 Present UPI value v/s GDP ratio

The status of UPI value and its impact on the economy in the present is shown in the percentage of GDP that has been contributed by UPI in the financial year of 2022-2023. This data is provided by “NPCI Statistics” (2023), and is simply a ratio, not a time-series and hence has no frequency. The real-time impact of UPI usage is what we aim to show here.

3 Methodology

Understanding the effects of technological adoption on the economy requires operating on data to gain insights. To this end, we use a simple methodology while evaluating time series data; which is to utilize the overall trend of the series to find out positive or negative impacts.

3.1 Cryptocurrency

3.1.1 Qualitative analysis

Our qualitative analysis follows a simple observation of the trends of our custom crypto index, paired with that of the GDP series taken over a similar course of time and frequency. Similar trends shall indicate positive correlations, while negative trends shall imply vice versa.

3.1.2 Quantitative analysis

Making sure of a robust analysis in order to understand the impact of cryptocurrencies on the economy via GDP, we employ a simple statistical analysis tool: the correlation coefficient between the series of UPI's contribution and GDP. We formalize the procedure as follows.

Given $X = \{x_i\}_{i=1}^N$ and $Y = \{y_i\}_{i=1}^N$ representing the custom crypto index and GDP series respectively over the selected time-frame of $N = 7$ months (from November 2022 to May 2023), we calculate the correlation coefficient r_1 between the two, given by

$$r_1 = \frac{\sum (x_i - \hat{x})(y_i - \hat{y})}{\sqrt{\sum (x_i - \hat{x})^2 (y_i - \hat{y})^2}}. \quad (1)$$

The correlation coefficient r quantifies the relation the variable X and Y . Particularly, r_1 which is constrained in the range $[-1, 1]$ denotes an increase in X with an increase in Y if it is positive (intensity of this increase is greater as $r_1 \rightarrow 1$). Similarly, a negative value of r_1 signifies a decrease in X with an increase in Y (intensity of this decrease similarly increases as $r_1 \rightarrow -1$).

3.2 Digital payments (UPI)

3.2.1 Qualitative analysis

Mainly, our time series trend analysis for UPI is done with respect to the Gross domestic product (GDP) of India. Gross domestic product at constant prices have been used as a proxy to measure economic performance in the country, and hence a trend in percentage contributions of the same is considered to be a significant indicator of positive impacts in our study.

3.2.2 Quantitative analysis

To ensure a robust analysis in order to understand the impact of UPI on the economy via GDP, we employ a simple statistical analysis tool: the correlation coefficient between the series of UPI's contribution and GDP. We formalize the procedure as follows.

Given $X = \{x_i\}_{i=1}^N$ and $Y = \{y_i\}_{i=1}^N$ representing the UPI and GDP series respectively over the selected time-frame of $N = 8$ years (from 2014 to 2021), we calculate the correlation coefficient r_2 between the two, given by

$$r_2 = \frac{\sum(x_i - \hat{x})(y_i - \hat{y})}{\sqrt{\sum(x_i - \hat{x})^2(y_i - \hat{y})^2}}. \quad (2)$$

The correlation coefficient r_2 quantifies the relation the variable X and Y . Particularly, r_2 which is constrained in the range $[-1, 1]$ denotes an increase in X with an increase in Y if it is positive (intensity of this increase is greater as $r_2 \rightarrow 1$). Similarly, a negative value of r_2 signifies a decrease in X with an increase in Y (intensity of this decrease similarly increases as $r_2 \rightarrow -1$).

We implement all quantitative analyses, as well as graphical plotting of our data in Python, using the Pandas, NumPy, SciPy, Matplotlib, and Seaborn libraries for effective data visualization and statistical operability.

4 Results

We present the data in the form of plots as well as the insights obtained from our analyses in this section. First, we show our data pertaining to cryptocurrency, notably, its adoption, value, and contribution to the economy. Trends in each cluster of data are presented along with their implications. Next, the display of data and its analysis with respect to digital payments (UPI) are presented similarly.

4.1 Cryptocurrency

This subsection shall contain the results of our methodology for cryptocurrency technologies.

4.1.1 Results of qualitative analysis

We begin by presenting the results or observations obtained via qualitative analysis of our custom crypto index series paired with the GDP series in the selected range from November 2022 to May 2023. In Fig. 5, we can see that both series seem positively correlated, seeing

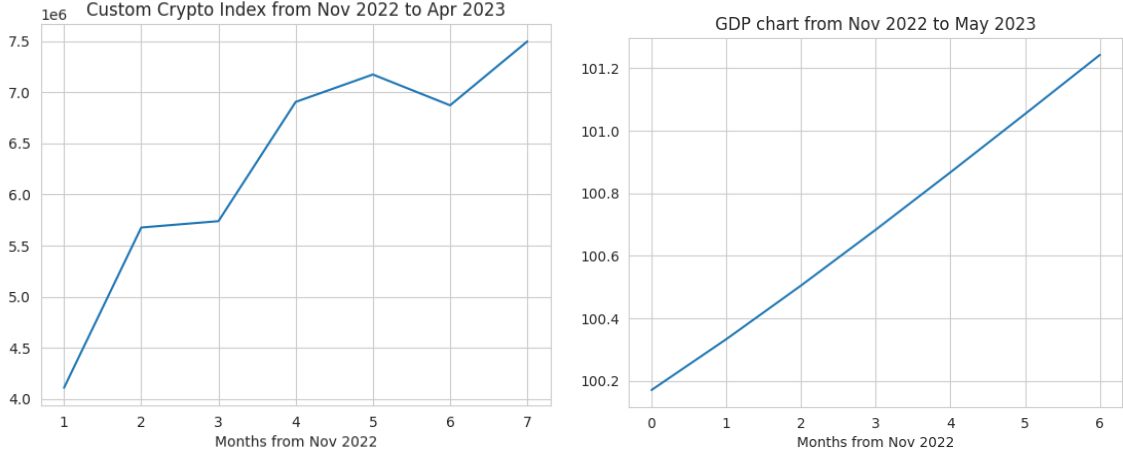


Figure 5: A visualization of both the series used for our analysis for cryptocurrency technologies.

relatively steadily increasing trends in the given time-frame. This may imply a positive correlation which we verify by our quantitative analysis.

4.1.2 Results of quantitative analysis

The correlation coefficient value that our quantitative analysis approach yields is consistent with the hypothesis and implications that our qualitative evaluation results offer. We calculate the correlation coefficients between our bespoke crypto index series and the real GDP series across the months, that is, from November 2022 to May 2023, as specified in our technique. The correlation coefficient r_1 is found to be 0.904 which is significantly positive and close to the maximum possible value for r_1 , which is 1.0. This confirms the observed implications in that, cryptocurrency usage and adoption leads to a positive impact on the GDP and the economy that the GDP becomes a proxy for.

4.2 Digital payments (UPI)

In this subsection, we present the results of our investigation on the impact of digital payments (UPI) on the economy of India.

4.2.1 Results of qualitative analysis

Firstly, we qualitatively analyze Fig. 6 and Fig. 7. In Fig. 6, it is clearly observed that the trend of UPI's percentage contribution to GDP is of an increasing nature, even to the extent of resembling an exponential curve to some degree. This implies a strong positive impact on India's economy via GDP as its economic proxy, since the GDP is also increasing.

Hence, we can observe the implication of a positive correlation with digital payment usage and adoption.

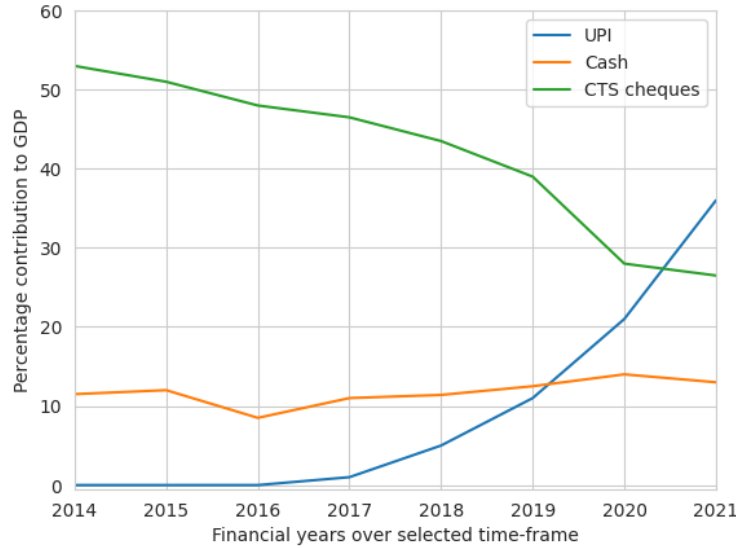


Figure 6: Modes of payment versus their percentage contributions to GDP (vertical axis) over the years (horizontal axis). *Source: “NPCI Statistics” (2023).*

Next, with respect to Fig. 7, we can see that the volume of money flowing through UPI transactions, as well as its value is at a strong rise throughout the period from April 2018 to April 2023. While we have selected a time-frame of 2014 to 2021 in our study, the volume and value of UPI transactions are negligible before 2018, being close to zero (also reflected in Fig. 6). Also, we extend the period in Fig. 7 to 2023 to tie in our analyses into the results of UPI’s share in the GDP of the financial year 2022-2023 which is 55%. Finally, Fig. 7 also shows the number of banks adopting UPI as a feature in their digital banking platforms, which also shows an increasing trends. Therefore, the observations made from Fig. 7 also imply a positive correlation of the economy with respect to UPI adoption.

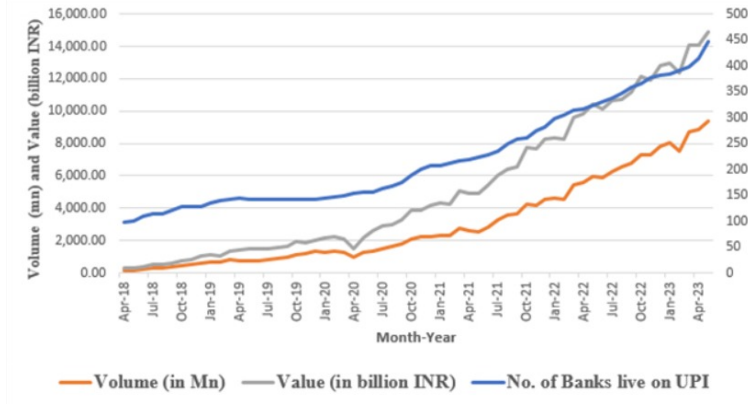


Figure 7: Volume of UPI transactions, value of UPI transactions, and adoption of UPI by banks over the years.

4.2.2 Results of quantitative analysis

Our quantitative analysis methodology results in a correlation coefficient value, which synergizes with the conjecture and implications presented in our qualitative evaluation results. As defined in our methodology, we compute the correlation coefficients between the UPI's GDP contribution series to the actual GDP series over the years, *i.e.*, from 2014 to 2021. Notably, the correlation coefficient r_2 is found to be 0.711 which is significantly positive and close to the maximum possible value for r_2 , which is 1.0. This verifies our conjecture and observed implications in that, digital payment (UPI) usage and adoption leads to a positive impact on the GDP, and by extension the economy.

5 Discussion and Proposals to Existing Policies

In light of the finding above, we realize the importance of technological adoption. Particularly with respect to the two technologies of cryptocurrency and digital payments that are studied in this paper, we provide proposals to the monetary policy and fiscal policy with regulatory measures to ensure that they can sustain and possibly improve the economic benefit imparted. These proposals are described in the following text along with the rationale behind them.

5.1 Proposals for cryptocurrencies

5.1.1 To monetary policy

1. **Proposal:** The Reserve Bank of India (RBI) could explore the development of a CBDC.

Rationale: This would provide a government-backed digital alternative to private cryptocurrencies, ensuring regulatory control while harnessing the benefits of digital currencies.

2. **Proposal:** Establish a regulatory sandbox specifically for crypto-related startups.

Rationale: This would allow controlled experimentation, fostering innovation in the crypto space while providing a framework for assessing risks and benefits.

5.1.2 To fiscal policy

1. **Proposal:** Introduce tax incentives for companies investing in blockchain technology.

Rationale: Encouraging businesses to adopt blockchain could streamline processes, reduce fraud, and enhance transparency.

2. **Proposal:** Explore the use of blockchain for government transactions, such as land registries and supply chain management.

Rationale: This could improve efficiency, reduce corruption, and enhance the traceability of transactions.

5.1.3 Regulatory measures

1. **Proposal:** Create a dedicated regulatory body for overseeing cryptocurrency exchanges and transactions.

Rationale: This would provide a centralized authority to enforce regulations, protect consumers, and curb illegal activities.

2. **Proposal:** Clearly define and communicate tax policies for gains from cryptocurrency transactions.

Rationale: Clarity in taxation can encourage compliance and reduce the likelihood of tax evasion.

5.2 Proposals for digital payments

5.2.1 To monetary policy

1. **Proposal:** Develop measures to enhance interoperability among various digital payment systems.

Rationale: This would ensure a seamless flow of funds between different platforms, promoting competition and innovation.

2. **Proposal:** Introduce incentives for businesses and consumers adopting UPI for transactions.

Rationale: Incentives such as cashback, discounts, or loyalty points could accelerate the adoption of UPI, reducing reliance on cash.

5.2.2 To fiscal policy

1. **Proposal:** Implement programs to encourage small and medium-sized enterprises (SMEs) to adopt UPI.

Rationale: Increased merchant adoption would lead to a broader acceptance of digital payments, providing convenience to consumers.

2. **Proposal:** Channel government subsidies and benefits directly through UPI.

Rationale: Direct benefit transfers through UPI can reduce leakages and ensure that subsidies reach beneficiaries efficiently.

5.2.3 Regulatory measures

1. **Proposal:** Streamline and digitize Know Your Customer (KYC) processes for UPI.

Rationale: Simplifying KYC procedures would make it easier for individuals to on-board onto UPI platforms, encouraging wider adoption.

2. **Proposal:** Introduce comprehensive data protection standards for UPI transactions.

Rationale: Clear standards would ensure the privacy and security of user data, promoting trust in digital payment systems.

6 Conclusion

Our study aims to understand impacts of digitization from the lens of economics. We investigate the impacts of adopting technologies of (i) cryptocurrencies (ii) digital payments (UPI) in the Indian economic setting for their prevalence and value given to the gross domestic product (GDP). We find strongly positive correlations of cryptocurrencies in a close window to the present. Digital payments via UPI also have a significantly positive correlation with GDP, more reliably however, as it holds for a longer window of time. Overcoming constraints of privatized data, we present this study and couple it with proposals to the Indian monetary policy as well as the Indian fiscal policy. Further, we support our proposals with regulatory measures as well.

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